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ABSTRACT

The stated purposes of this report are to assess the need for federally supported curriculum development in education and, if there is a need, appropriate policies for conducting development and supporting implementation. The assessment is based on the national curriculum development projects that have been sponsored since 1956 by the National Science Foundation (NSF). The report specifically presents: (1) a description of the curriculum innovations in a selected number of NSF national curriculum projects and a summary of the existing evidence regarding the classroom effectiveness of the curricula produced; (2) an assessment of the influence of the new curricula on programs produced by commercial publishers; (3) an assessment of the institutional factors favoring maintenance of the existing school curriculum; and (4) an assessment of the effects of national curriculum development on institutions in the curriculum policymaking system. Appendices and references are included. (DS)

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NATIONAL CURRICULUM PROJECTS
AND
DEVELOPMENT IN EDUCATION

by

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PREFACE

The purposes of this report are to assess: (1) the need for federally supported curriculum development in education, and (2) if there is a need, appropriate policies for conducting development and supporting implementation. The assessment is based on the national curriculum development projects that have been sponsored since 1956 by the National Science Foundation. The study is intended for use by federal policymakers and others in considering the role of national curriculum development in improving the quality of education and in determining strategies for supporting the development and implementation of school curriculum innovations.

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I. INTRODUCTION

The National Science Foundation's (NSF) first projects to improve education in the nation's public schools were "institutes" at universities where high school teachers could come to study and increase their knowledge of the disciplines of physics, chemistry, mathematics, or whatever their teaching specialty was. The first institute was at the University of Washington in the summer of 1953 for mathematics teachers.* Funding for these institutes eventually grew to be the major component of NSF's educational improvement program for elementary and secondary schools.

Funding for the development of improved instructional materials began in 1956 with the award of a grant to Jerrold Zacharias of the Massachusetts Institute of Technology for a feasibility study called the Physical Sciences Study Committee (PSSC). Zacharias's first-hand experiences in mobilizing teams of the nation's best scientific and engineering talent to develop advanced technology for the military in the post-World War II period were applied; a number of distinguished university scientists and high school physics teachers were invited to participate. After its first meeting, the PSSC steering committee issued a statement that its purpose was to "...evaluate the content of physical science courses hoping to find a way to make more understandable to all students the world in which we live and to prepare better those who will do advanced work."** The committee believed that students were not as aware as they should be "...of the part that physical science plays in forming the assumptions of their individual life and that of the community," and that the meaning of physical science for present society is "...as deep and important as that of the humanities and social studies."

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*Hillier Kreighbaum and Hugh Rawson, *Investment in Knowledge*, New York University Press, 1969.

**Paul E. Marsh, "The Physical Sciences Study Committee: A Case History of Nationwide Curriculum Development, 1956-61," EdD dissertation, Harvard Graduate School of Education, 1964, pp. 47-48.

Work soon began on an updated student text, a laboratory manual and equipment, a film series, achievement tests, a teacher's guide and resource book, and a series of paperback books providing authoritative science literature for students and adults.[*] Similar to procedures followed in technology development, the materials produced were tested in ordinary classrooms and revised on the basis of the results in successive stages to make the final products practical and effective for a broad range of students and teachers. This developmental method of bringing teams of scientists and teachers together at the national level to consider reforms in the school curriculum and carry through with the production of tested instructional materials was new to education. In the past, curriculum reforms had been advanced from the national level mainly through blue-ribbon committees of educators occasionally convened to rethink areas of education and issue general guidelines in the form of reports for local school districts and teachers to consider.[**] There was no accumulated knowledge or evidence from the field of education that either addressed the feasibility of this new method of *national development* or anticipated the problems associated with it.

HISTORICAL BACKGROUND

During the 1950s, there was a period of intense public concern about the *quality* of education in American schools, arising from several sources. Stemming from the war, there were problems of run-down and scarce school buildings to handle a burgeoning population of "war-baby" students.[***] Also, teachers were in such short supply that schools were frequently not able to fill positions with fully qualified personnel. For example, a report submitted to President Eisenhower in 1953 stated that the numbers of science and mathematics teachers being trained could not

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[*] Gilbert C. Finlay, "The Physical Science Study Committee," in Paul Rosenbloom, ed., *Modern Viewpoints in the Curriculum*, McGraw Hill, New York, 1964, p. 38.

[**] Lawrence A. Cremin, "Curriculum-making in the United States," *Teachers' College Record*, Columbia University, New York.

[***] Lawrence A. Cremin, *The Transformation of the School*, Vintage Books, New York, 1964, p. 338.

"...even provide for normal replacements at the present level, let alone take care of foreseeable growth."[*] More importantly, America emerged from the war as a much more complex and technologically oriented society and in a race for supremacy with the Soviet Union. Increasing the supply of highly trained manpower was seen as a matter of national survival, as laid out in a book called *Soviet Science Manpower*, published by the National Academy of Sciences, which greatly alarmed the Congress.[**] Academic professors, who had previously remained in their universities, suddenly found their services being demanded by the federal government. The successes of the scientists in the Manhattan Project and other war-related activities led to increasing belief that formal knowledge could make a significant contribution to human affairs and the formulation and execution of public policy.[***] Dow makes the association that against the background of societal concerns, this new stature naturally created a growing interest among academics in educational reform.[†] They began to speak out loudly that high school graduates were ill-prepared to handle even the most basic university courses and placed the blame on the poor quality of materials produced by publishers, on teaching practices, and on the education of teachers.[††] Publishers' materials were criticized as collections of miscellaneous facts devoid of unity and often seriously out-of-date, if not scientifically erroneous. Finally, the reaction to the progressive and life-adjustment movements in education that had been building since the early 1940s spread to the general public with the publication of Arthur E. Bestor's book *Educational Wastelands* in 1953.[*] Bestor charged that the post-Dewey progressives and life adjustment advocates had gotten the schools so involved in vocational activities and child-centered learning that the intellectual development of pupils had been lost. This book and several others that were published at the same time drove the final nails in the coffin of the progressive education movement that had started in the early 1900s. All these problems of inadequate school facilities and criticisms of the quality of instruction struck responsive chords among parents concerned for the future success of their children in a rapidly expanding society. Many of these parents had attended college for the first time under the G.I. bill, and this may have raised their expectations. Cremin has described this educational crisis as the deepest in the nation's history.[**]

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[*] Hillier Kreighbaum and Hugh Rawson, op cit., p. 164.

[**] Ibid., p. 187.

[***] Peter B. Dow, "Schooling and Soceity: Some Historical Perspectives on the Science Curriculum Reform Movement," Harvard University, unpublished paper, September 1975.

[†] Ibid., p. 45.

[††] National Science Foundation, "The Role of the National Science Foundation in Course Content Improvement in Secondary School," *School Review*, Vol. 70, No. 1, Spring 1962, p. 5; and Paul deHart Hurd, *New Directions in Teaching Secondary School Science*, Rand McNally, Chicago, 1971, p. 3.

Notwithstanding this crisis atmosphere, possibilities of direct federal aid for educational improvement were nil. Bills for general federal aid to education were introduced in every session of the Congress through the 1950s--as they had frequently been since the 1880s--and just as regularly they were defeated.[***] The problem was belief that providing the schools with aid would make them dependent on the federal government and open the door to subordination of the socially valued educational freedoms of communities and individuals to the needs of the state.[†] For example, because of these beliefs that federal money would lead to federal control of local school districts, a major education bill in 1950 died in the House Education and Labor Committee, despite passage in the Senate and the strong support of President Truman. In explaining the decision, Committee Chairman John Lesinski said:

> I have supported federal aid. I believe that a majority of this committee believes in federal aid. But I am convinced, after hard study we have put to the question, that no acceptable bill

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[*] Lawrence A. Cremin, op cit., p. 343.

[**] Ibid., p. 343.

[***] Stephen K. Bailey and Edith K. Mosher, *ESEA The Office of Education Administers a Law,* Syracuse, 1968, p. 21.

[†] Peter B. Dow, op cit.

> preventing federal dominance of local schools can be drawn. I reluctantly come to that conclusion, but I have to face the facts. This is the reason we have failed to report a bill.[*]

Congressional resistance to federal aid to education broke with the flight of Sputnik I in October 1957, which startled the country and seemed to confirm that the nation was indeed behind the Soviet Union in education and technical manpower. By 1958, the sentiment that the nation's future was tied to educational improvement became so intense that President Eisenhower urged the Congress to authorize special federal assistance to education in areas of national concern. On January 27, in a special address to the Congress, Eisenhower outlined an emergency educational program that called for a fivefold expansion in NSF's science education activities and for the passage of a new National Defense Education Act to provide programs in areas related to science and technology in the Department of Health, Education, and Welfare.[**] The assistance requested was categorical in nature and aimed at improving specific aspects of the educational system. Eisenhower acknowledged the importance of local control of education and stressed the transient nature of his proposed program. He noted: "Education best fulfills its high purpose when responsibility for education is kept close to the people it serves--when it is rooted in the home, nutured in the community, and sustained by a rich variety of public, private, and individual resources." He explained that the program was temporary and "should not be considered a permanent federal responsibility." The President's arguments were persuasive. Less than one year after Sputnik had been launched, the National Defense Education Act moved through Congress with relative ease and became law.[***]

THE NATIONAL SCIENCE FOUNDATION'S PROGRAM

In anticipation of the public response to Sputnik, NSF had quickly drafted an expanded program of activities and upon receiving Congressional approval, moved forward. The budget increase received allowed four more projects organized according to the PSSC model to be organized in other subject matter areas: the Biological Science Curriculum Study (BSCS), the Chemical Bond Approach (CBA), the Chemical Education Materials Study (CHEMStudy), and the School Mathematics Study Group (SMSG), the latter of which also included the elementary grades. A wave of expectation spread across the country that a revolution was coming in the school science and mathematics curriculum to solve the nation's educational problems. These five projects, including PSSC, are still the most widely known of all the national curriculum projects that NSF has supported.

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[*] *Elementary School Journal*, Vol. 50, May 1950, p. 486, as quoted in Peter B. Dow, op cit., p. 52.

[**] Dwight O. Eisenhower, *Recommendations Relative to Our Educational System*, Address to Congress, January 27, 1958.

[***] Elder Witt, et al., *Education for a Nation*, Congressional Quarterly Inc., Washington, D.C., 1962, p. 63.

Project Objectives

As the high school projects began to show promise, thinking turned to what could be done for the elementary grades. A series of conferences held around the country produced support for proceeding but with greater diversity of curriculum approaches, increased involvement of teachers, and more teacher training.* By 1962, several national curriculum projects were started along these lines. Similarly to the high school projects, the elementary projects sought to find ways of deepening understanding of science, but were much more sensitive to pedagogical issues and less concerned about upgrading subject matter content. Increasing the priority of science in the elementary school curriculum was seen as an important objective, since little science was being taught.

Many other national curriculum projects were initiated in the years after the elementary schools projects, as shown in Fig. 1, and Table I.1. Next to come were projects in the natural sciences for the intermediate grades and at all grade levels for the social sciences. Similar to the early high school projects, these projects were generally aimed at improving the existing discipline-oriented courses. Following this, the direction of development shifted from this orientation

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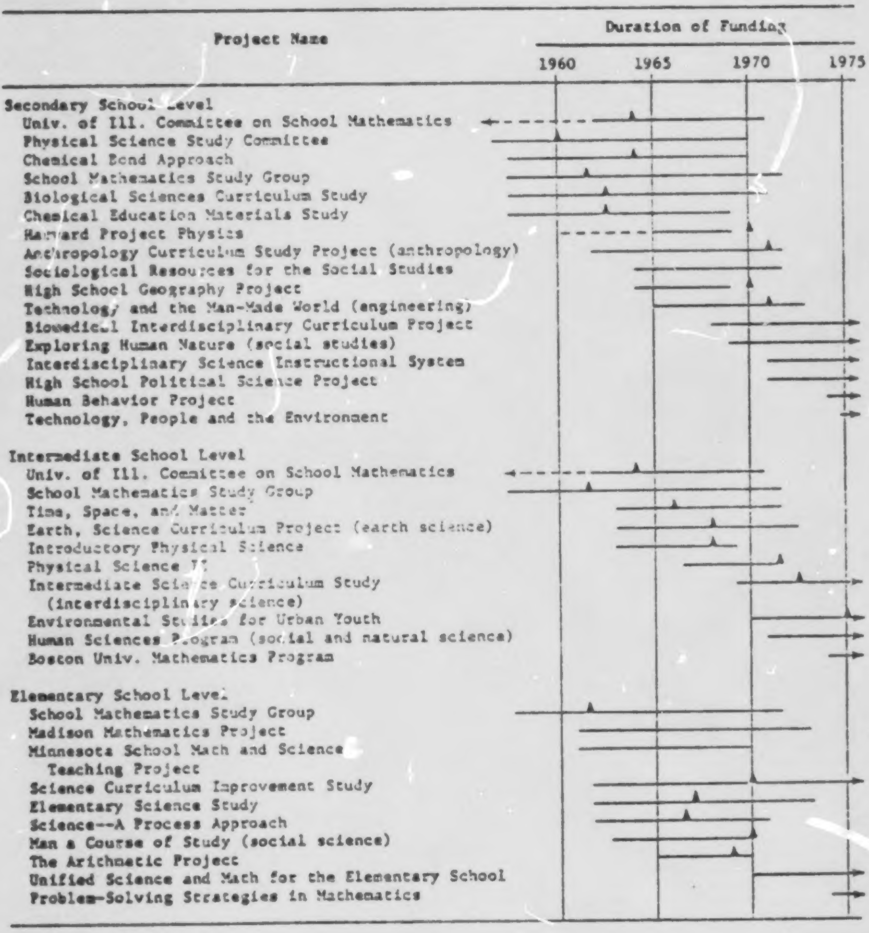
*"Science Teaching in Elementary and Junior High School," *Science*, Vol. 133, June 23, 1961, pp. 2019-2024.

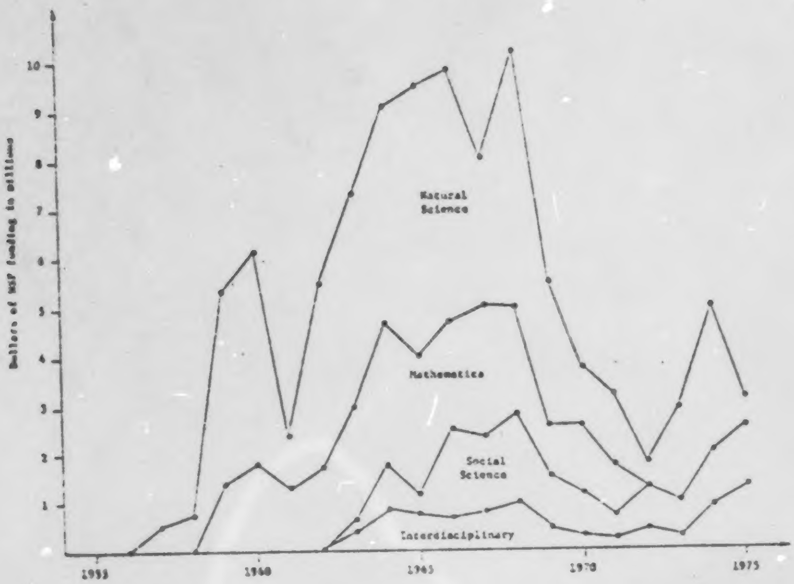
Table I.1

MAJOR NATIONAL CURRICULUM DEVELOPMENT PROJECTS OF THE NATIONAL SCIENCE FOUNDATION



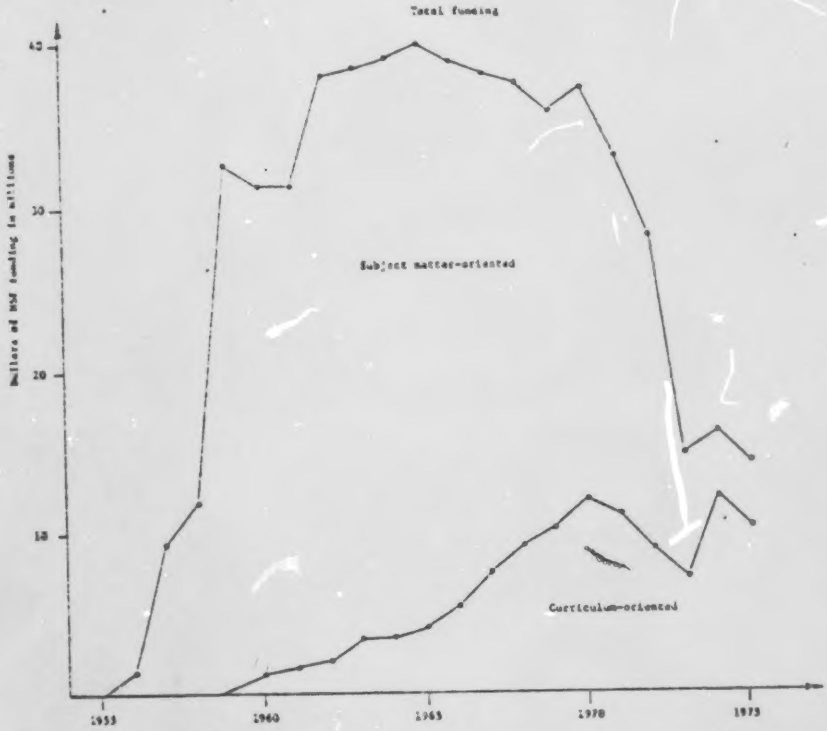
Key: —— NSF Funding
-- Other Funding (Office of Education, foundations)
▲ Copyright date of first edition of commercial materials

SOURCES: National Science Foundation, "Course Curriculum Improvement Projects," 0-547-651, Washington, D.C., 1974; "Pre-College Science Curriculum Activities of the National Science Foundation," Vol. II, pp. 171-176; and *El-Hi Textbooks in Print*, R.R. Bowker, for years 1965, 1970, and 1975.



SOURCE: Internal NSF study.

Fig. 1--NSF annual expenditures for curriculum development



SOURCE: U.S. House of Representatives, "The National Science Foundations and Pre-College Science Education: 1950-1975," Subcommittee on Science, Research, and Technology of the Committee on Science and Technology, 94th Congress, 2nd Session, January 1976, Appendix A, and an internal NSF report.

Fig. 2--NSF funding of inservice teacher training activities to producing problem-oriented curricula. The difficult challenge taken up in these projects is to create educational experiences that are addressed to problems that are socially important and interesting to students, but can be approached through knowledge from the scientific disciplines. Since few social problems fit neatly into one of the scientific disciplines, these curricula all involve the integration of knowledge from several disciplines into a course of study and imply fundamental reorganization of the school curriculum from a discipline-oriented to a problem-oriented structure.

Total Funding

A total of over forty national curriculum projects have been supported by the NSF since 1956. Total expenditures rose rapidly after the Sputnik year to a peak of about $10 million in the mid-1960s and then began to decline. In the aggregate, NSF has invested approximately $100 million in development over a period of 18 years.*

As shown in Fig. 2, NSF has also spent about $640 million since 1953 for teacher institutes and other teacher training activities. Eighty-three percent of these funds, or $532 million have been for traditional institutes and other training activities to provide opportunities for teachers to increase their knowledge of the scientific disciplines without regard for any specific NSF curriculum. The remaining 17 percent, or $110 million, has been spent on teacher institutes and other training projects intended for the implementation of specific NSF-developed curricula.** These projects cover subject matter but are mainly limited to what is included in the new curricula. In addition, these projects focus on the teaching methods incorporated in the new curricula and techniques for classroom implementation. Nearly all of these curriculum-specific implementation projects have been supported since 1965.

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*Fig. 1.

**Fig. 2.

NSF Strategy

NSF did not direct all of its teacher training funds to curriculum-specific implementation activities in the early years for two main reasons.[*] First, NSF staff believed that teachers' lack of subject matter competence was a bigger problem in improving science education than poor teaching methods or difficulties in using new materials. Second, NSF staff judged that directing training funds to the implementation of the new materials might be interpreted by Congress or others as a move by the federal government to take over science education in the schools, which might lead to disabling controversies. A policy was established that the new materials developed by the curriculum projects would have "to make their way on their own merits." No effort was made to solicit proposals for curriculum-specific implementation projects; but, if submitted, such proposals were reviewed on an equal basis with proposals for subject matter-oriented training activities.

In addition to materials development and teacher training, NSF also funded a number of other less well-known activities intended to improve science education. Support was provided starting in the late 1950s for a series of commissions in different subject matter areas (e.g., mathematics, biology, and physics) to recommend improvements in college curricula. Although the direct target of these commissions was undergraduate education, NSF hoped that any resulting changes would create incentives for corresponding changes at the elementary and secondary levels. Some of these commissions turned directly to recommending improvements in teacher education, which have subsequently had considerable impact.[**] In co-sponsorship with a private foundation, NSF also supported a commission to recommend improvements in state teacher certification criteria and processes. NSF allowed the early high school curriculum projects to invest in the development of achievement tests and did not dissuade them from influencing the College Entrance Board to change their tests. And NSF has experimented over the years with a number of different ways to improve the quality of pre-service teacher training programs in schools of education.

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[*] This paragraph and the remainder of this subsection are based on an interview on March 19, 1976 with Bowen Dees, a former NSF Assistant Director for Education.

[**] Committee on Mathematical Education, "Overview and Analysis of School Mathematics," Conference Board of the Mathematical Sciences, Washington, D.C., 1975, p. 82.

NSF's overall approach in the early years for improving science education was unique in relation to the strategies of the subsequent federal programs to reform education, mostly funded through the U.S. Office of Education. The approach was shaped by several institutional and social factors: the social climate of educational concerns in the post-war period; the NSF's mission to be the leading federal science agency and its early stage of development; the pathbreaking nature of the educational improvement effort; and the inclinations of the initial program leaders. The approach was not fully articulated nor highly formalized. It was more a set of working assumptions shared by the staff.

First, the general goal of the program was to improve the *quality* of science education (and to achieve a more uniform distribution of quality among schools) as opposed to directly increasing the quantity of scientific and technical manpower. The NSF education staff rejected large programs to simply subsidize the training of more teachers or to influence the career choices of students, which were inconsistent with NSF's mission to support excellence in science and with the prospects of obtaining the necessary funds. The agency had only been created in 1950 and as late as 1958 had a total budget for all of its programs of less than $50 million.* The expectation was that improving the quality of science teaching would both improve the preparation of students later chosing to pursue scientific or technical careers and deepen the understanding of science and technology of those who did not, making them more cognizant as citizens of science and technology's role in society. The belief was that these objectives were more responsive to the national need for technological superiority than simply increasing the supply of science and technical manpower.

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*U.S. House of Representatives, Hearings Before the Subcommittee on Science, Research, and Development, Committee on Science and Astronautics, 91st Congress, 1st Session, Vol. II, March 17, 1969, p. 10. Referring to Fig. 2, total funding of teacher training activities was more than 25 percent of the total NSF budget in 1958.

Second, funds were not directed to the final target of students in classrooms but to *intermediate points of entry* in the education system, because of the budget limitations and staff convictions that in the long-run this would be a more effective use of federal funds. As indicated above, many different possible points of entry were seen, including the college curriculum, pre-service teacher education, inservice teacher education, and materials development. No single point of entry was seen as controlling and, furthermore, lack of prior federal experience made it impossible to specify "optimal" modes of intervention at any of the points. Therefore, NSF saw advantages in experimenting with different modes of intervention at several points of entry and attempting to learn from the results. The intent was to find modes of intervention that would have "multiplier effects"* in that the changes that occurred would be substantial in relation to cost, long lasting, and rich in side effects. Materials development was particularly seen in this way as providing models which textbook writers, publishers, and schools might emulate. NSF carefully attended the formulation of copyright and royalty policies that would strike a proper balance of incentives for publishers to gain from marketing the nationally developed materials and to incorporate ideas from the materials in their own products, while avoiding windfall gains to individuals or organizations from the public investments in development. Pursuing a variety of approaches to improving science education also allowed NSF to avoid appearances of imposing federal solutions to educational problems.

Third, the means that NSF chose in intervening were typically *integrative rather than programmatic*, in the sense that funds were directed to activities for bringing personnel who would ordinarily not be mutually involved in educational improvement activities into association rather than to build intergovernmentally administered programs. Because of NSF's institutional base in science, scientists were the natural fulcrum for these associations. Thus, the curriculum development projects involved scientists and teachers; the teacher training efforts included scientists and teachers and also professors of education; the teacher certification effort included scientists and state administrators and representatives of teacher education; and so forth. The intent was that these associations would generate and give visibility to ideas for educational improvement that would ordinarily not gain currency and that the prestige of the scientists would provide impetus for change. This approach was taken partly because NSF's institutional charter did not provide authority to work through the state departments of education that OE had, but also because the staff believed that building bridges among existing sources of influence on the school curriculum was more likely to be successful in the long-run than channeling money directly to the schools through administered programs. Clark distinguishes this approach as a mode of influence somewhere between a purely political system and a formal bureaucratic strategy of organization.[*] NSF sought to influence the system of existing institutions influencing the school curriculum rather than to build a new and separate system of influence. While most of these associations were only funded temporarily, others became more institutionalized. The most prominent example is the teacher training institutes.

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*The term "multiplier effects" was used by Bowen Dees in the March 19, 1976 interview.

EDUCATION IN THE 1960s

By the mid 1960s, the nation's crisis of scientific and technological incapacity had begun to fade and new social currents were rising to the surface. The federal courts began to enforce the 1954 Supreme Court school desegregation decision, causing some violent confrontations that brought the educational plight of blacks clearly into public view. Racial demonstrations and civil rights marches in the South culminated in the Civil Rights Act of 1964, which added full federal authority to the Supreme Court's desegregation decision by outlawing discrimination in all federally aided programs. Growing affluence in white suburbs made the poor more obvious in the decaying central cities and remote rural areas, raising poverty to a public issue.[**]

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[*] Burton R. Clark, "Interorganizational Patterns in Education," *Administrative Science Quarterly*, Vol. 10, 1965, pp. 224-237.

[**] Stephen K. Bailey and Edith K. Mosher, op cit., Chapter 1.

The watershed for education was the Elementary and Secondary Education Act (ESEA) of 1965, which for the first time channeled massive federal aid to the schools for specific kinds of changes. Title I directed federal funds ($600 million in the first year, increasing to $1.5 billion by 1970) through state agencies to local school districts in proportion to their populations of economically disadvantaged. Title III provided grants to local school districts for projects to stimulate locally initiated change in any educational area and for all educational groups. Title IV allowed for the establishment of several regional laboratories to conduct educational R&D, which formally institutionalized the concept of national development. Other titles were for grants to local school districts to purchase library and other material resources and to State Departments of Education.

ESEA Title I was a national policy statement that education is obligated to provide the economically disadvantaged with learning opportunities that are equal to those enjoyed by the affluent. The program supplied funds directly for services but also brought pressure on states and local districts to turn their attention to the economically disadvantaged, including the increase of their own resources. This was a fundamental change from the 1950s and early 1960s when the number of programs for the gifted that a school system had and the number of students bound for renowned universities with advanced placement credits were the criteria of success.

Following the precedent of Title I, Congress has in recent years passed a flood of similiar legislation to establish policies that the needs of other special population groups like the handicapped and non-English speaking students also have to be met. Thus, during the late 1960s and into the 1970s, federal educational policy has been directed toward access to an equal education by influencing school districts to provide resources for services to compensate for the different special needs of their clientele.

ESEA Title III was intended to improve the quality of education through simulating a generally higher level of innovative activity in local school districts.[*] Funding of Title III rose quickly after its passage to about $150 million per year until its consolidation with a few other federal programs in the Education Amendments of 1974. In sharp contrast to the NSF strategy, Title III funds went directly to local school districts for locally initiated innovative projects and could be spent for a wide variety of purposes ranging from the purchase of materials and supplies, hiring staff, and training teachers, to planning and materials development. Because of the way that Title III is funded, there are no strong incentives for school districts to reach out and cooperate with each other or with personnel in other educational institutions. Depending on the nature of individual projects and the perspective from which project acitvities are viewed, Title III can be seen as a program to develop educatonal models and resources for national use, to demonstrate models of innovative educational practice locally as an inducement for adoption by others, or to support local problem-solving. By not being associated with national development or being linked to other educational institutions, Title III is based on the premise that educational innovation is fundamentally a local process blocked more by lack of financial resources than educational knowledge or organizational capability. The Title III idea of improving education through locally initiated innovative projects has been incorporated in the legislation and administrative regulations of many other OE programs. A prime example is the ESEA Title VII Bilingual Education program, which supports the development of curriculum materials and tests, teacher training methods and materials, and many other activities--all through local school districts.

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[*] Stephen K. Bailey and Edith K. Mosher, op cit., pp. 54-55.

In response to accountability pressures, findings from studies like Coleman's *Equality of Educational Opportunity* that more dollars do not significantly affect student achievement, and numerous evaluations of federally funded projects showing "no significant difference," OE officials have over recent years worked to devise organizational strategies and administrative procedures for identifying and validating "successful" federally funded projects in local school districts and supporting the dissemination and utilization of these projects across the country. Part of this effort has been to experiment with "packaging" these successful projects into material forms to facilitate local implementation. The search has been for "solutions" to problems of providing for special educational needs and improving educational quality that local school districts may have found and that can be transferred to other school districts and serve as demonstrations of "how to do it." Although it is probably too early to assess the overall progress of these efforts, the direction is to build an intergovernmental structure for supporting development in local school districts and communicating the results to other school districts, in sharp contrast to the NSF strategy.

The policy analytic profession that grew up in the 1960s has pushed empirical analysis of *controlled experiments* in local settings as a strategy of finding solutions to educational problems and improving federal programs. For example, the Planned Variations program has tested different models for early childhood education in the schools. Another initiative has been to conduct experiments on ideas for "marketizing" educational services, such as performance contracting and educational vouchers. Generally, the amount of policy-relevant information generated by these experiments has been disappointing.[*]

A new school of policy analysis, drawing on organization theory, is asserting that the problem is not the lack of solutions but failure to fully implement solutions at all governmental levels and particularly in local school districts. The diagnosis is that the success of federal programs is more contingent on the organizational capability of local school districts to implement change than on the power of innovations such as new curricula.[**] Recommendations are to redirect federal policy away from seeking better innovations to increasing the organizational capacity of schools to innovate.

CRITICISMS OF THE NEW CURRICULA

Educators, the public, and, certainly, the curriculum reformers were initially excited about the promise that the national curriculum projects and the NSF program seemed to hold for improving education.[*] The textbooks from the School Mathematics Study Group (which became known as the "New Math") swept into the schools and almost completely replaced older materials.[**]

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[*] Alice Rivlin and P. Michael Timpane, *Planned Variations in Education,* Brookings Institution, Washington, D.C. 1975.

[**] Paul Berman and Milbrey McLaughlin, "Federal Programs Supporting Change in Education, The Findings in Review," The Rand Corporation, R-1589/4-HEW, Vol. IV, April 1976.

When ESEA established a new agenda for education that the new curricula, designed for the needs of the previous decade, could not serve. Even Jerome Bruner, the intellectual spokesman of the curriculum reformers (whose book, *The Process of Education,*[***] became the treatise on their work), was moved to conclude that "...the first order today... (is) redressing the deep, deep wounds that we inflict on the poor, the outcast, those who somehow do not fit within our caste system--be they black or disposed in any way..."[†] He continued: "...the concern (is) no longer to change the schools from within by curriculum, but to refit them altogether to the needs of society, to change them as institutions."[††]

Also, a reaction to the new curricula began to set in with charges that the new curricula were too abstract and difficult for students,[†††] had done little to change the quality of teaching, and increased fragmentation of the school curriculum.[‡] Earlier than the organizational theorists, Silberman wrote in *Crisis in the Classroom*[‡‡] that the curriculum reformers had run aground on the harsh realities of schools in trying to bypass teachers with materials, and so emphasized the subject matter of their disciplines that they had disastrously overcompensated for the child-centeredness of the Progressives. In *Why Johnny Can't Add*,[*] Kline expressed the dissatisfaction of many that the "New Math" was excessively abstract and seriously deficient in providing basic computational skills. At the peak of these reactions, the generation of new elementary school curricula--many different in form and substance from the earlier high school projects--began to reach the schools (see Table I.1). But by the late 1960s, the momentum for national curriculum development was lost.[**]

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[*] Lawrence A. Cremin, *The Genius of American Education,* University of Pittsburgh Press, Pittsburgh, 1965, p. 53; and Robert W. Heath, ed., *New Curricula,* Harper and Row, New York, 1964.

[**] Richard O. Carlson, "School Superintendents and the Adoption of Modern Math: A Social Structure Profile," in Matthew Miles, *Innovation in Education,* Teachers College Press, New York, 1964, pp. 329-341.

[***] Jerome S. Bruner, *The Process of Education,* Harvard University Press, Cambridge, 1960.

[†] Jerome S. Bruner, "The Process of Education Reconsidered," in Robert R. Leper, ed., *Dare to Care/Dare to Act,* Association for Supervision and Curriculum Development, Washington, D.C., 1971, p. 22.

[††] Ibid., p. 26.

[†††] Paul deHart Hurd, *New Directions in Science Teaching,* Rand McNally and Company, Chicago, 1971, pp. 47-50.

[‡] Lawrence A. Cremin, op cit., p. 60.

[‡‡] Charles E. Silberman, *Crisis in the Classroom,* Random House, New York, 1970, pp. 179-183.

LOCAL PERSPECTIVE

In counterpoint to these national-level currents of criticism and shifting priorities, McKinney and Westbury have described the curriculum changes that actually occurred in one local school district over the decades of the 1950s and 1960s due to NSF's national development.[***] Their findings point to the need for assessment of national development in a much broader context than that taken by most critics.

Through 1956, the science curriculum in the high schools of this school district had not discernibly changed for many years and was similar to the science curriculum in most schools across the country.[†] One science course was required for graduation, and most students took either general science in the 9th grade or biology in the 10th grade. Physics was available in all eight of the district's schools but chemistry in only four. Only two schools had laboratories and there were no advanced courses.[*] The same textbook series had been used in many classes for over 15 years.[**]

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[*] Morris Kline, *Why Johnny Can't Add*, St. Martin's Press, Inc., New York, New York, 1973.

[**] Edward J. Meade, *A Foundation Goes to School*, The Ford Foundation, 1972, p. 26.

[***] W. Lynn McKinney and Ian Westbury, "Stability and Change: The Public Schools of Gary, Indiana, 1940-1970," in *Case Studies in Curriculum Change*, William A. Reid and Decker F. Walker, eds., Routledge and Kegan Paul, London, 1975, pp. 1-53.

[†] Ibid., p. 24.

In 1956, a curriculum committee was formed for the purpose of improving the high school science program--the first such effort in the district's history. The committee was formed in response to a report by a school board-commissioned external review group that was critical of the district's programs and its lack of curriculum improvement capability.[***] After two years of work, the committee produced a curriculum guide specifying that all schools should have a complete offering of beginning and advanced science courses in all disciplines. The committee had difficulty recommending content for these courses, so they simply listed chapter topics from leading textbooks.[†]

No change occurred until 1960[††] after one of the district's science teachers had attended an NSF summer institute for PSSC, became enthusiastic about what he heard, and persuaded a colleague that they should both use the new PSSC materials in their courses. Interest in the new materials spread; by 1966, almost all of the district's physics teachers and supervisory personnel had attended NSF institutes, and PSSC materials were being used in all classrooms. Similar patterns developed in chemistry and biology, so that by 1968 nearly all science classes in the district were using the new NSF materials. Also, new courses were added in bio-physical science, physical science, second-year chemistry and physics in all schools. Courses were differentiated as to method and purposes so that students could select those meeting their needs.[†††] At least in rhetoric, the earlier conception of science as a body of fact had been replaced by science as a process of enquiry. New or remodelled laboratories were constructed in all schools.[*]

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[*] Ibid., p. 24.

[**] Ibid., p. 26.

[***] Ibid., p. 26.

[†] Ibid., p. 28.

[††] Ibid., p. 25.

[†††] Ibid., p. 24.

In 1969 the NSF materials were replaced with more conventional, but new, textbooks. Many of the teachers had not liked--or did not know how to use--the new materials; the movement gained influence when one of the science supervisors taught a course with the new materials and discovered some of the problems in these materials. The new courses and the laboratory facilities remained.[**] Lack of training capability in the school district or continuing access to outside expertise may have been a factor in this retrenchment.

Several important phenomena concerning national development are illustrated in this case study. First, the school district had little capability to undertake developmental change on its own and consequently the normal mode of operation was no change.[***] Second, when change occurred, the initiative was local but depended upon resources provided from outside the system by national development. The critical resources were the new NSF materials and the teacher institutes.[†] These resources provided the science staff with a new program that enabled them to obtain funds from the school district for the new courses and the laboratories. Third, the structural changes of new courses and the laboratories--which are what the local staff initially wanted--persisted, while use of the NSF materials did not. However, the case study did not determine the extent to which innovations in the NSF materials were incorporated by the teachers in their teaching and selection of subject matter, or in the replacement materials that were adopted. The structural changes of upgrading the priority of science subjects in the schools and improving laboratories were objectives of the national development effort, if not all that the developers wanted to accomplish. This illustrates how national development can simultaneously have many different objectives and produce effects through many different channels. The changes that occur in any particular local setting may be strongly related to factors of that setting.

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[*] Ibid., p. 24.

[**] Ibid., p. 30.

[***] Ibid., p. 44.

[†] Ibid., p. 31.

RECENT POLICY CONCERNS

After the decline in enthusiasm for national development in the late 1960s, federal support for it has become an issue again in the last two years.

In 1975, Congressman Conlan charged that the NSF sponsored Man A Course of Study (MACOS) curriculum was "threatening and repugnant"[*] to parents in "scores of communities"[**] across the country and that NSF had used the financial resources of the federal government to impose MACOS and other courses on local school districts,[***] reactivating the federal control of education issue and plunging NSF's science education program (and the whole agency) into a deep controvery. Several reviews of NSF's science education program have been conducted[†] and in 1976 the Congress terminated all funds for the implementation of specific curricula. The appropriations for national development have been continued but at a lower level than the peak of $10 million in the late 1960s.

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[*] U.S. House of Representatives, Congressional Record - House, April 9, 1975, H. 2585.

[**] Ibid.

[***] Ibid. Also H. 2586.

[†] U.S. House of Representatives, Committee on Science and Technology, "National Science Foundation Curriculum Development and Implementation for Pre-college Science Education," 94th Congress, 1st Session, November 1975; General Accounting Office, "Administration of the Science Education Project: Man A Course of Study," MWD-76-26, October 14, 1975; National Science Foundation, "Pre-college Science Curriculum Activities of the National Science Foundation," Report of the Science Curriculum Review Team, Vols. I and II, May 1975; U.S. House of Representatives, Subcommittee on Science, Research, and Technology of the Committee on Science and Technology, "The National Science Foundation and Pre-college Science Education 1950-1975," 94th Congress, 2nd Session, Science Policy Research Division of the Congressional Research Service, Washington, D.C., 1975.

The National Institute of Education's Curriculum Development Task Force conducted a review during 1976 in the course of preparing recommendations to the Institute's National Council on Educational Research regarding policies that should be established for NIE support of national curriculum development. Based on interviews with representatives of educational organizations, a series of commissioned issue papers, and a conference, the Task Force found great divergence of opinion regarding the success of past curriculum reform efforts (including NSF national curriculum projects) and needs for national curriculum development in the future. The Task Force generally attributed this lack of consensus to basic value differences and the inadequacies of existing information on the results of past curriculum reform efforts. The Task Force recommended a policy to the Council of: (1) flexibility in deciding whether national curriculum development provides the most advantageous means of responding to an educational problem or opportunity, (2) support only for development that is not being or will not be undertaken by commercial textbook publishers or other agencies in the education system, and (3) requiring that federally supported development not proceed beyond the production of a few exemplary instructional units unless a determination of need and effectiveness is made.*

PURPOSES OF THIS STUDY

These recent policy concerns heighten a longstanding need for policy-oriented analysis of NSF's program of national development. First, as we have described in this chapter, national development is a distinctive approach to educational reform, and therefore its strengths and weaknesses need to be understood. National development may or may not need to be an important component of the educational R&D system that is emerging under the leadership of the NIE.[*] Second, the amounts that NSF has spent per year on national development are much smaller than the levels of funding for other federal programs. Therefore, national development may be attractive from the standpoint of cost in comparison to results. Third, NSF's program has not been comprehensively analyzed, even though it is widely known and there is a long history of activity. Current opinion on the merits of NSF's national development effort has been influenced mostly by informal observation of the results that were achieved, the recent political controversy over a few of the projects that were supported, and the displacement of educational concerns from the issues of the 1950s to the issues of the late 1960s.

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*"NIE's Role in Curriculum Development: Findings, Policy Options, and Recommendations," prepared by Jon Schaffarzick and Gary Sykes, Curriculum Development Task Force, and submitted by Harold L. Hodgkinson, Director to the National Council on Educational Research, Washington, D.C., February 8, 1977.

The most numerous kinds of existing studies of national curriculum development are historical accounts of individual national curriculum projects, typically authored by the project director or key staff members.[**] These accounts contain useful information but tend to be descriptive rather than analytical. The two most comprehensive analytical studies in existence are Hurd's review of the impacts of the Biological Sciences Curriculum Study on secondary biology education,[***] and a review of the "New Math" by the Conference Board of the Mathematical Sciences. Hurd lays out some desirable characteristics of an impact study and then proceeds to summarize the available evidence on the adoption of BSCS materials, effects of inservice training activities on teachers, incorporation of BSCS ideas in teacher education, and effects on curriculum research. Based on an analysis of textbook and test content, and a questionnaire survey of a sample of teachers, the

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[*] Ward Mason, *The Status of Education Research and Development in the United States: 1976 Data Book*, Dissemination and Resources Group, National Institute of Education, Washington, D.C.

[**] Arnold B. Grobman, *The Changing Classroom: The Role of the Biological Sciences Curriculum Study*, Doubleday and Company, Inc., New York, 1969; Richard J. Merrill and David W. Ridgeway, *The CHEM Study Story*, W.H. Freeman and Company, San Francisco, 1969; Emily Romney and Mary Jane Neuendorfer, *The Elementary Science Study - A History*, Education Development Center, Inc., Newton, Massachusetts, 1973; and William Wooten, *SMSG: The Making of a Curriculum*, Yale University Press, New Haven, Connecticut, 1965.

[***] Paul deHart Hurd, "An Exploratory Study of the Impact of BSCS Secondary School Curriculum Materials," *The American Biology Teacher*, Vol. 38, No. 2, February 1976, pp. 79-85.

Conference Board finds that the "New Math" content innovations (K-12) and emphasis on student understanding of unifying concepts and structures have resulted in "substantial improvement" in the school mathematics curriculum, but have certainly fallen short of "the euphoric promise of 1960."[*] Also, Welch has called for the need to assess national curriculum projects and has summarized existing evidence on the extent of adoption for secondary science courses.[**] Schulman and Tamir have reviewed the educational research literature on the pedagogical issues raised by the national curriculum projects.[***] The central issue for policy is whether federal support for national development is needed. Federal support for *development* is justified only to the extent that there are needs for educational improvement that cannot be met through developmental activity and for which existing developmental capability in the education system is inadequate. Federal support for *national development* is justified only to the extent that it is more effective than state or locally based approaches. As described in this chapter, a strong federal role in national development has been politically feasible only in times of intense social crisis. These crises have defined the general area of need for improvement. While national development may be justifiable only as a means of assisting the education system in responding to crises, it is also possible that crisis has been a symptom of more basic incapacities in the education system allowing performance gaps to accumulate over time until they become critical. Such incapacities would justify a more deliberate, although not necessarily continuous or all-encompassing, federal role in national development. Thus, the primary issue to which this report is addressed is the *appropriate role for national development in the improvement of education.* The key words are *development,* as opposed to experiment, demonstration, or other modes of innovative activity; and *national,* as opposed to private, state or local.

A second important issue, which follows from the first, is the selection of *preferred policies in supporting national development.*

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[*] National Advisory Committee on School Mathematics, op cit., p. 21.

[**] Wayne Welch, "The Impact of National Curriculum Projects. The Need for Accurate Assessment," *School Science and Mathematics*, Vol. LXVIII, No. 3, March 1968, pp. 225-234.

[***] Lee Schulman and Pincus Tamir," Research on Science Teaching," in Robert M. Travers, *The Second Handbook of Research on Teaching*, Rand McNally, Chicago, 1973.

The analytical need is to determine if there are policies that produce greater effects on education than others consistent with maintaining local responsibility for education. Several policy variables have been indicated in this chapter, including the composition of the development team, whether development should or should not be carried through the production of finished materials, different forms of inservice teacher training, and most importantly, whether implementation should be viewed as a much larger problem than simply inservice training of teachers in the use of new materials. For example, NSF's funding of activities in institutions other than the schools was integral to their overall approach to curriculum improvement. Analysis of these policy variables is complicated by the possibility that indirect effects of national development on these other institutions may be more significant than through direct usage of the materials produced in the schools. One clear example is the effect (which NSF foresaw) that the curricula produced by the national curriculum projects would serve as models for publishers in producing their own instructional materials. More broadly, NSF's program introduced the developmental process into education--in the sense of seeking improvements through knowledge-based efforts to find and empirically verify new ways of meeting learner needs--and any assimilation of this process into the education system would be significant. NSF's approach in the early days of sponsoring integrative activities at intermediate points of entry into the educational system is potentially a model for a more effective federal role in supporting educational development.

Analysis of these two issues--the appropriate federal role in supporting national development and preferred support policies--requires more definition of different kinds of developmental needs, identification of policy alternatives available to the federal government, and assessment of existing developmental change capabilities in education. In the next chapter, we present a conceptual structure specifying the variables and providing the theoretical basis for our analysis.

II. CONCEPTUAL FRAMEWORK

The account of NSF's program of national development in the previous chapter provides the points of departure for constructing the conceptual framework for this study. For the purpose of improving the quality of education, national development is concerned with designing changes in the core relationships in classrooms among teachers, students, and subject matter--i.e., with extending the *technology* of schooling. We will call these core relationships the *school curriculum*. Incorporation of the intended changes occurs through federally supported implementation activities, as well as indirectly through *institutions* in the education system having influences on the school curriculum. In addition to the schools, these institutions include many other public and private institutions, such as publishers and schools of education. Lack of developmental capability in these institutions results in stability over time, or in maintenance of the existing school curriculum. Maintenance is disfunctional when needs and opportunities for quality improvement arising in the *social and knowledge environments* of education go unmet. The potential role for national development is to assist these institutions in responding to these environments. Thus, our conceptual framework has three main components: the school curriculum (technology), institutions, and environments.

In considering all three of these components at once, we are moving beyond traditional research in the fields of curriculum and educational innovation, which have previously been separate. Research in the curriculum field has been primarily concerned with formulating theories of education and the construction of logical frameworks for proceeding from theory to the specification of learning experiences--which is a purely technological orientation.* Problems of innovation, or bridging the gap from technological design to integration in local schools, have been pursued by other researchers, but usually from the perspective of the general innovative process in education.** The classical approaches to the study of educational innovation include the RD&D model (research, development, and diffusion), the social-interaction perspective, and several theories of organizational change.[*] This research has been mainly concerned with identifying the institutional and environmental conditions conducive to change and with finding improved implementation strategies. The unit of analysis in these studies is typically the school (or the local school district) on the usually unstated assumption that other institutions in the education system have little influence on what changes occur at the school level. In this study, we approach the assessment of national development as a problem of understanding interactions among curriculum technology, the many institutions in the education system, and their environments. Each of these components and interactions among them are specified in detail below.

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*William A. Reid, "The Changing Curriculum: Theory and Practice," in William A. Reid and Decker F. Walker, op cit., pp. 240-241.

**Ibid., p. 244.

THE SCHOOL CURRICULUM

There are almost as many conceptions of the school curriculum as there are authors who have approached the subject. For some, curriculum is the outcomes of instruction and for others the inputs of learning experiences provided for students. Some consider the curriculum to be what is intended as "desirable" or "ideal" and which may be formally written into syllabuses or statements of objectives. Others think of the curriculum as being the actual activities in classrooms, which may be far different from stated ideals. Lastly, observers have seen two wholly different curricula in classrooms: the agenda of academic subjects being pursued and what children learn without being taught from the social organization of schools. The latter has been variously called the "hidden" or "unstudied" curriculum.[**]

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[*] For reviews of these approaches, see William A. Reid, ibid., and Ronald G. Havelock, "Planning for Innovation Through the Dissemination and Utilization of Knowledge," Center for Research on the Utilization of Scientific Knowledge, Institute for Social Research, University of Michigan, Ann Arbor, 1971.

[**] Norman V. Overly, ed., *The Unstudied Curriculum: Its Impact on Children,* Association for Supervision and Curriculum Development, Washington, D.C., 1970, and Philip W. Jackson, *Life in Classrooms,* Holt, Rinehart, and Winston, New York, 1968.

Components of the School Curriculum

Common to all definitions of the school curriculum is some notion of subject matter (what is learned) and interactions in the process of learning (how learning is facilitated in the classroom). In keeping with our view of curriculum as the technology of schooling, we will define the school curriculum to be the *structure of subject matter* and the *learner's modes of interaction with subject matter* in the actual classroom setting. We limit our definition of curriculum to intended subject matter and modes of learning as they would be revealed through classroom observation.

The Structure of Subject Matter. Subject matter in the school curriculum is structured in *content* and *skill orientation*. Content refers to the ordered bodies of knowledge introduced into the classroom. These bodies of knowledge may be scientific, philosophic, artistic, or practical--like accounting or vocational trades. Content in the school curriculum is structured into *subject areas*, into what we will call *content strands* within these subject areas, and further into *topic sequences* within these strands. Four broad categories of skills are perceptuo-motor, cognitive (thinking and remembering), linguistic, and social-emotional (valuing, role-taking, moral reasoning, and so forth).* Others might select a different categorization, but these will serve the purposes of this study. The cognitive category is the most important for this study since this is mainly where the NSF projects attempted to change the school curriculum. Subject matter and skills are independent measures of the school curriculum to the extent that a skill can be acquired from different subject matter. For example, certain thinking skills can be taught through the subject areas of biology, chemistry, and so forth.

Learner Interactions with Subject Matter. Learner interactions with subject matter differ in modes of *representation, assignment and knowledge acquisition*, and *social grouping*.

Bruner postulates that intellectual growth requires mastery of three different modes of representing, or modeling, subject matter.** *Enactive*

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*Senta Raizen, et al., *Design for a National Evaluation of Social Competence in Head Start Children*, The Rand Corporation, R-1557-HEW, November 1974.

**Jerome S. Bruner, *Toward a Theory of Instruction*, Harvard University Press, Cambridge, 1967, pp. 10-23.

representation is learning subject matter through direct manipulation of objects, as in adding through counting beans or rocks, etc. *Iconic* representation is presenting subject matter through images, as in learning to add through pictures drawn on the blackboard or in learning concepts of social organization by seeing movies depicting differences in the lives of primitive tribes, bees, baboons, and so forth. Image experiences can have powerful effects on perceptual organization.* *Symbolic* representation is acquiring information through symbols and language, as in studying physics through mathematical equations or culture from reading books. Representing subject matter in different orders may have strong effects on intellectual development, e.g., Piaget asserts that "the true cause of failures in formal education is essentially the fact that one begins with language instead of beginning with real material and action."**

The mode of subject matter assignment and knowledge acquisition refers to the control exercised by the learner in pursuing subject matter. Assignment refers to the locus of authority in selecting subject matter for study, and knowledge acquisition to the ensuing discourse and activity. To the extent that coverage of subject matter is programmed by teachers or physical technology like books or tests, and students are restricted from questioning or expanding upon what they are studying, learner control is *passive*. At the other extreme, learner control is *active*, inasmuch as students influence choices among subject matter topics and are encouraged to inquire.

The social grouping in a classroom refers to the pattern of social interaction in learning situations. Students may work independently, with other students in groups with minimal guidance from the teacher, or directly with the teacher. One view is that social interaction is essential to learning not only in the social-emotional area but in all other skills.***

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*Bruner, op cit., p.

**Jean Piaget, *To Understand is To Invent*, Penguin Books, New York, 1976, p.

***Ibid., p.

These components will be mainly used for assessing the *status of the school curriculum* at points in time and in describing the directions in which NSF's program of national development attempted to move the technology of schooling. Each component can be refined into subcomponents and then, at least conceivably, actual practices in the school can be observed and compiled. High degrees of *regularity* in components and subcomponents of the school curriculum would be observed if practices were uniform from school to school. Conversely, high degrees of *diversity* in components and subcomponents of the school curriculum would be observed if practices were very different from school to school.

Curriculum Philosophies

Choices in each of these components concern the social functions of the schools and are therefore highly value-laden. Alternative conceptions of these social functions, interwoven with elements of pedagogy into loosely connected education philosophies, can be identified in educational writings and forms of schooling. The value implications of these conceptions are often sharply divergent and therefore a major source of conflict in curriculum change.

Academic Rationalism. Among these conceptions, one is *academic rationalism*, where the social function of the schools is conceived to be enabling the young to participate in the Western cultural tradition by providing access to the culture's "greatest ideas and objects."[*] For the most part, these ideas and objects are to be found in the established arts and scholarly disciplines. Intensive study of these disciplines, it is argued, supplies meaning to social existence and develops the intellectual capacity of the mind to think precisely and reason effectively. This philosophy has roots in the school of mental disciplinarians in the 1800s, who insisted on the virtues of studying certain subjects like the classics for developing the powers of the mind, but continues to find expression in the school curriculum. As we shall see in Chapter III, the early NSF high school science projects in many ways were consistent with this philosophy but also extended it.

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[*] Elliott Eisner and Elizabeth Vallance, *Conflicting Conceptions of Curriculum*, McCutchan, Berkeley, 1974, p. 12.

Personal Development. A second concept is *personal development*, where the function of schooling is conceived to be helping each student develop to their fullest potential and to accept responsibility for their own education--in or out of school. The philosophy is that each student has a different potential for growth in all cognitive and social-emotional areas and that schooling should enable growth in all of these areas. Ultimately, students should achieve a personal integration of their knowledge and emotions with their environment.[*] The teachers' role is to design educational experiences arouding curiosity and stimulating discussion so that students come to accept responsibility for their own education and learn how to make choices.[**] Education is conducted as a dynamic process of interaction between environments and personal processes rather than a one-way transmission of the cultural heritage (as in academic rationalism). This philosophy has found expression in many progressive schools in the mid-1900s and in current forms of education that follow from the research over the last several decades in child development psychology. In the latter, learning in cognitive areas is typically stressed over social-emotional areas.

Adult Life. A third concept is that the function of schooling is to prepare children for adult life through training in the needed skills. For the good of society, adults should be able to earn a livelihood, contribute to the polity, and be functionally literate; thus, schools should provide vocational and career-oriented training, teach government and instill the duties of citizenship, and ensure mastery of basic abilities in language, reading, writing, and arithmetic. Some would round out learning in these areas with courses in physical health and recreational activities.

Schooling has conformed more closely to this philosophy than either academic rationalism or personal development. Partly this is due to pressures from the industrialization of society.[***] The most influential individual has been Franklin Bobbit, a professor at the University of Chicago. In 1924, he expounded a theory that "... education's fundamental responsibility is to prepare for the fifty years of adulthood, not for the twenty years of childhood and youth..."[*] Based on Taylorian principles of industrial efficiency, he specified that the means of achieving this should be to analyze scientifically the activities of adults to discover objectives for the school curriculum. These objectives were to be specified in detail and then appropriate learning experiences designed. This model of curriculum development, intended to formulate achievement goals and the design of appropriate learning experiences from these goals, defined the professional field of curriculum and has been the guide for curriculum work in the schools to this day.[**] Bobbit's model has been further elaborated by Tyler and others.

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[*] Elliott W. Eisner and Elizabeth Vallance, op cit., p. 9.

[**] J. Minor Gwynn and John B. Chase, *Curriculum Principals and Social Trends*, 4th Edition, MacMillan, London, 1969, pp. 44-45.

[***] Raymond E. Callahan, *Education and the Cult of Efficiency*, University of Illinois, 1962; and David B. Tyack, *Turning Points in Educational History*, Xerox Publications, Lexington, 1967.

Social Reconstruction and Relevance. A fourth educational philosophy is social reconstruction and relevance, which purports that schools should be an agent for social change.[***] Reconstructionists argue that the schools should be a force for remaking present society into the society of the future; while advocates of social relevance only see that schools should deal with the important social issues of the day to provide the "crucial context" for developing the capability of individuals to adapt to social change. Both are seeking to improve the ability of individuals to fit into society; the former by educating individuals to actively shape social change, and the latter by educating to cope with rapid social change. Some of the early progressives, like Counts, were reconstructionists, as was Illich. Advocates of the adaptive approach urge that "real life" problems should be brought into the school and schooling should be conducted out in the community.[†]

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[*] Franklin Bobbit, *How to Make a Curriculum,* Houghton Mifflin, Boston, 1924, p. 8.

[**] Elliott W. Eisner, "Franklin Bobbit and the Science of Curriculum Making," *The School Review,* Vol. Spring, 1967; and Lawrence A. Cremin, "Curriculum Making in the United States," *Teachers College Record,*

[***] Elliott W. Eisner and Elizabeth Vallance, op cit., p. 10.

[†] Ibid., pp. 10-12.

CURRICULUM RESOURCES

To go beyond impact evaluation of NSF's activities to issues of the federal role and strategy in supporting national development, we need a theoretical model of the curriculum change process.

Curriculum Innovations

Ideas for restructuring subject matter or a student's mode of interaction with subject matter in the school curriculum will be called curriculum *innovations*. These innovations can be at the component or subcomponent level of the school curriculum. We do not consider whole school innovation, such as an "open classroom" to be an innovation. Rather, an "open classroom" can take many different forms, depending on the innovations that are used. Thus, the "idea" of introducing economics into the school curriculum as a subject area is an innovation at the component level; the introduction of macroeconomics in the content of a school's economics may be an innovation at the content strand, subcomponent level.[*] An idea in this sense is an innovation only in relation to non-using individuals or organizations, since almost "every idea has been an innovation" for someone, somewhere, at some time.[**]

Model of Curriculum Development Process

A curriculum development project will be modeled as consisting of: a *platform*, an interrelated set of innovations comprising the curriculum *design*, *deliberation*, and *empirical assessment*.[***] The platform is the development team's shared consensus on values and beliefs, assessment of need, and vision of what ought to be in the school curriculum. The platform is akin to an educational philosophy but more narrowly focused on a particular curriculum problem.[*] Preliminary conferences to obtain expert opinion and other needs assessment activities can be conducted in forming this consensus. *Development* is the process of converting the platform into a curriculum design and the design into an array of curriculum products embodying the design through deliberation and empirical assessment. Deliberation is the process of formulating decision points, inventing alternative choices at these decision points, considering arguments for and against suggested division points and alternatives, and finally making choices.[**] Early in development, the deliberative process tends to be *inventive* as the design is formulated. Later,development tends to become more *evaluative* as the design is converted into products, although the transition is gradual. The activating principle in deliberation is the desire for defensibility; for the justifiability of decisions in terms of the platform, accepted principles and empirical evidence.[***] Empirical evidence may be obtained from trying out preliminary versions of the products embodying the curriculum's design; or, from existing research. In the course of arriving at defensible alternatives, the deliberative process is also *informative*--or knowledge-producing--with regard to the causal mechanisms, interaction effects, and value implications of the curriculum design and its component innovations. This knowledge is understood by the developers who are therefore the resource persons with regard to the innovations in the curriculum design.

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[*] Herbert W. Voege, "The Diffusion of Keynesian Macroeconomics through American High School Textbooks," in William A. Reid and Decker F. Walker, op cit., pp. 208-239.

[**] Everett M. Rodgers and F. Floyd Shoemaker, *Communication of Innocations*, Free Press, New York, 1971, p. 19.

[***] Decker F. Walker, "A Naturalistic Model for Curriculum Development," *School Review*, Vol. , November 1971, pp. 51-65. Walker contrasts this model of curriculum to the classical model advanced by Bobbit and others, which was described earlier in this chapter, where the major elements are the objective and the learning experience. In this model, the logical operations are "... determining objectives, stating them in proper form, devising learning experiences, selecting and organizing learning experiences to attain given outcomes, and evaluating the outcomes of those experiences," Our formulation of Walker's naturalistic model adds empirical assessment as a fourth major component.

From this model, there are three main *curriculum resources* from curriculum development: an interrelated set of *curriculum innovations* comprising a curriculum design, *curriculum products* embodying these innovations, and *resource personnel,* as diagrammed in the center-most box in Fig. II.1.

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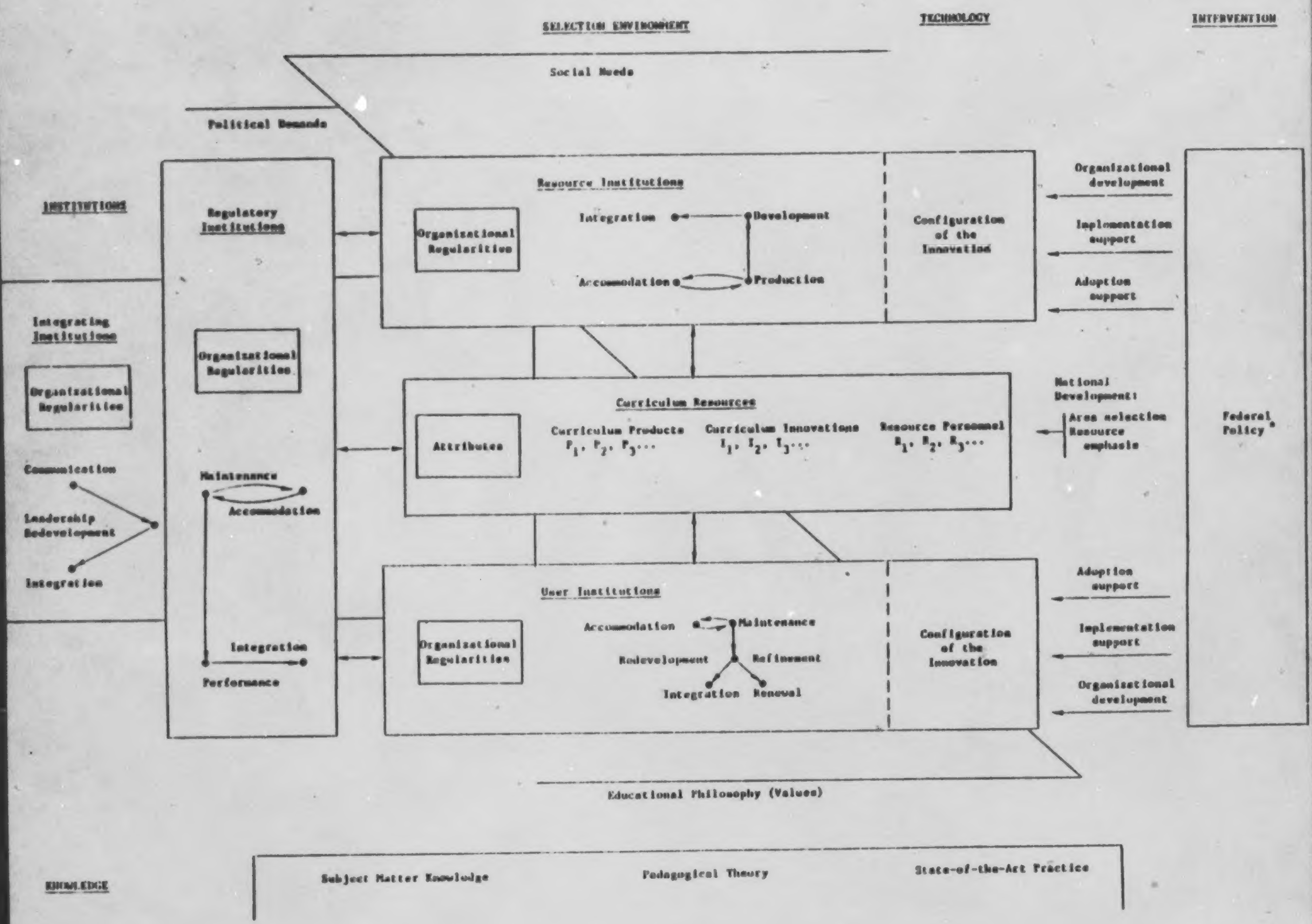
[*] For example, a brief version of the "platform" for PSSC was quoted on the first page of Chapter I.

[**] Ibid.

[***] Ibid.


SELECTION ENVIRONMENT
TECHNOLOGY
INTERVENTION
Social Needs
Political Demands
INSTITUTIONS
Regulatory Institutions
Resource Institutions
Organizational Regularities
Integration
Development
Accommodation
Production
Configuration of the Innovation
Organizational development
Implementation support
Adoption support
Integrating Institutions
Organizational Regularities
Organizational Regularities
Curriculum Resources
Attributes
Curriculum Products P_1, P_2, P_3...
Curriculum Innovations I_1, I_2, I_3...
Resource Personnel R_1, R_2, R_3...
National Development:
Area selection
Resource emphasis
Federal Policy*
Communication
Leadership Redevelopment
Integration
Maintenance
Accommodation
Integration
Performance
User Institutions
Organizational Regularities
Accommodation
Maintenance
Redevelopment
Refinement
Integration
Renewal
Configuration of the Innovation
Adoption support
Implementation support
Organizational development
Educational Philosophy (Values)
KNOWLEDGE
Subject Matter Knowledge
Pedagogical Theory
State-of-the-Art Practice

*NOTE: Federal policy can also be to support intervention in regulatory and integrating institutions.

Fig. II.1--Curriculum change model

Curriculum Innovations

The innovations produced are what distinguish national development from other federal interventions in education. National development advances specific changes in the technology of schooling to improve the quality of education.

These innovations may be considered together as a design for the school curriculum or as ideas for separately changing components (and subcomponents) of the school curriculum. Few curriculum innovations are so interdependent that they cannot be used independently.[*] As we will see, this property determines the character of implementation processes. Furthermore, the *same innovation can be common to the designs of several national curriculum projects.* For example, the innovation of organizing subject matter content around the "structure of the discipline"[**] was an innovation advanced by several of the early high school science projects.[***] The significance of this is that use in the schools of an innovation common to several national development projects in different subject areas would shift the entire school curriculum in the direction of this innovation even though the other parts of the project design might not be used. Also, the complexities of schooling (and the inevitable biases of the development team) make it difficult for any single development project to produce a design that will be equally appropriate for intact use in all classrooms. One project may advance subject matter innovations, another pedagogical innovations, and users may select which are most appropriate for them. Thus, national development can be viewed in two different ways: *programmatically*, where the intent is to have the designs from national projects be used intact, or for the purpose of creating a *technological environment*, where the innovations produced are useful as resources in user-developed designs.

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[*] James D. Thompson, *Organizations in Action*, McGraw Hill, 1967, pp. 15-18 distinguishes between long-linked and intensive technologies. Curriculum innovations are intensive technology.

[**] Joseph J. Schwab, "The Concept of the Sturcture of a Discipline," in Elliott W. Eisner and Elizabeth Vallance, op cit., pp. 162-175.

[***] The concept of the "structure of discipline" is an innovation shifting the cognitive orientation of the school curriculum to a higher level.

Curriculum Products

The products embodying innovations from national development may include student materials, classroom equipment, teacher's guides, teacher training materials, procedural specifications, testing instruments, and so forth. The same innovation may be embodied in several different products from a project. For example, the "structure of a discipline concept" may be embodied by a national project in student and teacher materials, tests, and even laboratory equipment (e.g., PSSC-organized content around the conceptual structure of physics not only in writing text materials but also in developing many new pieces of scientific apparatus for illustrating this structure in the laboratory. Product development can be carried through the production of *finished materials* ready for layout and printing by publishers, including several cycles of trial and revision in the schools; or, terminated earlier in either *preliminary versions* of the materials or in *proto-type versions* of sample units. An advantage of the two latter alternatives is lower development cost. A disadvantage may be that use of the innovations produced will be less. Finished materials may be critical to the change process.

Resource Personnel

The resource personnel from a national project include all who may have participated in the development process, including possibly academic subject matter specialists, psychologists, educators, practitioners, (teachers and supervisory personnel), and even staff of publishing houses, testing organizations, and so forth. Most of these personnel return to their home institutions at the completion of the national project and may use the knowledge that they gained to effect changes in their home institutions.* A project with a temporary form of organization could produce more of these personnel than a project conducted solely by the staff of a *permanent* organization.

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*Another possible effect from participation in a national project that we shall not assess is career enhancement. National development provides unique professional growth opportunities for the participants.

These personnel are particularly important because the knowledge produced during development about innovations is typically informal. It is rarely codified and verified at the theoretical level by the developers during development. Development projects normally do not have the resources to conduct the necessary research to codify the knowledge produced nor is the environment of tight deadlines and the necessity of dealing with practical realities conducive to accomplishing this.

Research from Development

The theoretical and empirical issues raised by development can attract the interest of the research community to the extent that capability exists in the education system. The psychological research that was stimulated by the innovation of organizing subject matter around the structure of the discipline is one example.* This by-product may be to verify, qualify, extend, or even refute an innovation. If the capacity to respond in the research community is weak, federal policy could be to follow up on development with support for this kind of research in order to capitalize on the informal knowledge generated during development.

ROLE OF DEVELOPMENT IN EDUCATION

The role of curriculum development is to assist the education system in responding to the social environment through converting opportunities created by advances in knowledge into curriculum resources.

Knowledge Environment

Advances in knowledge are the main sources of curriculum innovations. These advances can be either in formal or informal knowledge. Formal knowledge is produced by the scholarly disciplines; for curriculum, the disciplines in science, art, and the humanities ,

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*Jerome S. Bruner, *The Process of Education*, Harvard University Press, Cambridge, 1960, p. 6. A different kind of example is the work that has been done on he policics of the biological concept of evolution, the introduction of which into the high school biology curriculum was an innovation advanced by BSCS. See Dorothy R. Nelkins, "Science Textbook Controversies," *Scientific American*, as concerned with subject matter,are distinguished from the branches of psychology, as concerned with pedagogy. Advances in subject matter knowledge create opportunities for innovation in the structure of subject matter, while advances in pedagogical theory create opportunities mainly for innovation in the mode of interaction with subject matter. For example, the innovations in the School Mathematics Study Group (SMSG) of organizing subject matter content around mathematical concepts came from advances in mathematical theory during the early 1900s. A classical example from psychological theory is Thorndike's research on the learning of arithmetic published in 1922 as *The Psychology of Arithmetic.* Thorndike stressed the need to learn not only basic facts but reasoning as well, the proper organization and amount of practice in various skills and the elimination of the unnecessary "bonding" that occurred when rare vocabulary words or exotic contexts were employed in arithmetic problems, among other innovations.[**] Informal knowledge is produced through the creative activity of teachers and educators to advance the art of educational practice. In many fields, the contributions of a technology's craftsmen to advancing the state of the art have been found to be a more important source of innovations than knowledge from related scholarly disciplines; this is especially true when, as in education, the formal knowledge base is weak.[***]

Social Environment

Needs for curriculum innovations arise in the social environment of education. One kind of need is when social changes occur having implications for the school curriculum. This was the case in the 1950s when the need arose to improve national scientific and technological capability. Other examples have been amply documented by educational historians: national independence in the late 1700s, which created the need to replace British with American history, literature and government in the school curriculum to aid in separating the political

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[*] E.G. Begle, "Curriculum Research in Mathematics,"in *Research and Development Toward the Improvement of Education,* Herbert J. Klansmier and George T. O'Hearn, Wisconsin Center for Research and Development in Cognitive Learning, University of Wisconsin, 1968, pp. 44-48.

[**] Lee J. Cronback and Patricia J. Suppes, *Research for Tomorrow's Schools,* MacMillan, London, 1969, pp. 96-110.

[***] Derek J. de Solla Price, op cit.

and intellectual culture from its English origins; frontier expansion and the democratization of politics, which gave rise to the need for common schools; successive waves of foreign immigration, which brough needs to stress oral language and socialization of the country's values and traditions; and the industrial revolution, which pressed norms of efficiency and models of bureaucratic organization on the schools, as well as needs for curriculum in areas displaced from family life, such as the domestic and industrial arts, and physical education.[*] Sometimes these needs may become highly politicized as in the late 1950s and at other times may persist at low levels of politicization. Another kind of need is for the education system to generate innovations responsive to the pluralism in society, different philosophies of education, and the differences among individual students. Because these needs may not be highly politicized, the education system would have to develop the capacity to identify them and generate the necessary curriculum resources. This implies the capacity to generate a *diversity* of curriculum resources. Cremin argues that schooling is now more than a mediating institution with diverse relationships to other social institutions, ranging from the family to religion, industry, the law, and the media, and that there is a great need to understand the educative functions of these other institutions and to devise complementary forms of schooling and curriculum.[**]

Development Capacity

Development is the capacity of institutions in the education system to convert knowledge into resources to meet these social needs. The developmental capacity of the education system is *performance-oriented* to the extent that knowledge is converted into curriculum resources as it is produced, social needs are met before they become critical and politically intense, and the needs of different clientele groups are evoked and curriculum resources generated to meet their needs.* Because of diversity in society and educational values, a diversity of curriculum resources would be produced. Development produces *innovations*--ideas for restructuring subject matter and modes of learning--in contrast to incremental changes in the school curriculum, which continually occur. These incremental changes are mostly at the subcomponent level of the school curriculum in subject matter topics and techniques for teaching those topics. Over time, incremental changes may accumulate to produce substantial change in relative emphasis in the school curriculum among content areas and modes of learning but the process is disjointed and slow. Thus, lack of capacity for development in the education system results in stability and regularity of the school curriculum over time and significant change mainly in reaction to crises.

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[*] David B. Tyack, *Turning Points in Educational History*, Xerox Publishing, Lexington, Mass., 1967; Raymond E. Callahan, op cit., and Walter Doyle, "Education for all: The Triumph of Professionalism," in O. L. Davis (ed.), *Perspectives on Curriculum Development, 1776-1976*, Association for Supervision and Curriculum Development, Washington, D.C., 1976.

[**] Lawrence A. Cremin, *Public Education*, Basic Books, Inc., New York, 1976. For a review of the several studies done in the vein urged by Cremin, see Michael Timpane, et al., *Youth Policy in Transition*, The Rand Corporation, R-2006-HEW, June 1976.

Need for National Development

Lack of capacity in the education system for needs assessment and development is justification for a federal role in supporting national development. Policy alternatives are: (1) to support development directly or through means intended to increase the development capabilities of existing institutions, and (2) to support development on a continuing basis or periodically as needs are diagnosed and knowledge opportunities arise or mainly in response to crises; and (3) for the whole school, or in selected subject areas at selected grade levels.

INCORPORATION OF CURRICULUM INNOVATIONS

Justification of a federal role in supporting national development also requires determination that the innovations generated will be used in the schools. For this we need a model of the process of incorporating curriculum innovations in the education system. Similar to development, our model will be that *incorporation* of curriculum innovations is determined by a system of ongoing institutions in the education system in interaction with their social/political environments. Incorporation is the continuing process of assimilating an innovation in an institution.

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*A similar formulation can be found in John Friedman, *Retracking America: A Theory of Transactive Planning*, Anchor Press, Garden City, New York, 1973, pp. 159-165.

Institutions

We include institutions external to the schools because of their influence on the school curriculum. Therefore, incorporation of curriculum innovations by these institutions external to the schools may have important effects on the school curriculum, requiring that our model of the incorporation process encompass this possibility. Incorporation needs to be analyzed in a framework of interorganizational relationships among institutions in the education system.

In an article published in 1964, Wayland discussed the implications for educational innovation of the institutions that are, as he called them, "ancillary" to the formal organizational structure in American education, which is the U.S. Office of Education, state departments of education, and local school districts.[*] He noted that while the formal structure is highly decentralized, based on the principle that schools should be locally autonomous, in fact there is a high degree of uniformity in the school curriculum. He argued that much of this uniformity is because of the influences of these ancillary institutions. He warned that "innovations which do not take (the resulting) . . . character of the system into account will encounter difficulties."[**] Campbell and Koerner identified more of these external institutions and described their effects on the school curriculum in more detail.[***] Kirst and Walker carried the argument further in characterizing these institutions as comprising the policymaking process in curriculum.[†] They stressed the highly political nature of this process and that it is largely outside the formal education system.

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[*] Sloan R. Wayland, "Structural Features of American Education as Basic Factors in Innovation," in Matthew Miles (ed.), *Innovation in Education*, Teachers College Press, Columbia University, New York, 1964, pp. 587-614.

[**] Ibid., p. 598.

[***] James D. Koerner, *Who Controls American Education?*, Beacon Press, Boston, Massachusetts, 1968; and Ronald Campbell (ed.), *Nationalizing Influence on Secondary Education*, Midwest Administration Center, University of Chicago, Chicago, Illinois, 1963.

[†] Michael W. Kirst and Decker F. Walker, "An Analysis of Curriculum Policy-making," *Review of Educational Research*, Vol. 41, No. 5, pp. 479-508.

For our purposes, we will distinguish four classes of institutions which may incorporate curriculum innovations. First, curriculum innovations may be incorporated by the schools as the *user* institutions in the education system. Second, curriculum innovations may be incorporated by the *resource institutions* in the education system that supply curriculum products and resource personnel either to the schools or other institutions in the education system. These institutions include publishers, schools of education, and curriculum development centers. Incorporation may be in the resources supplied by these institutions and in their organizational structures. For example, an innovation can be incorporated in the curriculum materials produced by publishers and, depending on its nature, in plant and equipment. Third, there are *regulatory institutions* in the education system, so called because their policies and decisions affect decisions made in user and resource institutions. These institutions include, among others, state textbook adoption boards, certification agencies, and testing organizations.* Since regulatory institutions do not produce products, incorporation can be only in their activities and organizational structures. Fourth, innovations may be incorporated by the many specialized associations that exist in the education system among members of the other institutions in the education system, which we will call *integrating institutions*. Integrating institutions include professional teacher organizations, scientific societies, publishers' trade associations, state adoption board administrators groups, and so forth. Incorporation of innovations in these integrating institutions can facilitate the incorporation of innovations in other institutions.

In effect, resource, regulating, and integrating institutions are *intermediate points of entry* into the education system for curriculum innovations. Federal policy could be to support incorporation of curriculum innovations in these institutions to the extent that *higher*

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*In one sense testing organizations are a resource institution since tests are a product supplied to the schools. But for the purposes of this report, testing organizations will be considered to be a regulatory institution since this product influences decisions on innovations made in user and resource institutions.

leverage is provided on the school curriculum than through entry at the school level. The *degree of leverage* provided is the change in the school curriculum produced as a result of incorporation at one of these intermediate points of entry in relation to the costs to the federal government of achieving this incorporation. Later in this chapter, we will identify these intermediate institutions and discuss their influences on the school curriculum in more detail.

Configuration of Innovations

We define the extent of incorporation of an innovation to be its manifestations in an institution's policies, organizational structure and functions, budgets, decisions, methods and procedures for performing tasks, behaviors and skills of individual members, and materials employed or produced, like manuals, equipment, and other learning aids. For example, the incorporation of the innovation of organizing subject matter around the concepts of a discipline in a publisher's text materials can be measured by defining criteria for paragraph-by-paragraph classification of the extent to which concepts are presented and related to subject matter. Then the comparisons could be made among different texts and over time to assess incorporation.[*] Or, similar criteria could be used to assess the incorporation of this innovation in the guidelines issued by state adoption boards to publishers and local school districts as policies regarding preferences among alternative instructional materials. In other words, we define the extent of incorporation to be the *observable* changes consistent with an innovation in the structure and functioning of an organization. The pattern of manifestations will be called the *configuration of the innovation* in an institution.[**] The composite of these configurations reveals the technology being used by that institution, as indicated in Fig. II.1.[***]

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[*] An analysis of this kind will be done in Chapter V.

[**] This concept of the configuration of an innovation was suggested by Gene T. Hall, University of Texas, Austin.

[***] The composite of configuration of all innovations would be a measure of the status of the school curriculum.

As indicated by the examples in the previous paragraph, this concept of the configuration of an innovation provides a means of tracing the use of an innovation over time among institutions. The procedure would be to select criteria for deciding whether an innovation is in use in each of the categories that we identified: policies, organizational structure and functions, budgets, decisions, behaviors, materials, and so forth. Some categories might not be appropriate for some innovations. Then data could be collected in a sample of institutions over time and the results compiled. The compiled data would be a multivariate time series.[*]

Adoption. One property of these time series variables is that increases in their values would show the extent of *adoption* of an innovation over time.[**] Two adoption phenomena that will be important in this study are the *first instance* of use of an innovation in an organization and its *lateral spread* within the organization .

Adaptation. Another property is that these time series would typically show many different configurations or *adaptations* of an innovation among and within organizations at any point in time and change in these configurations over time.[***] Adaptation is the mutual process of fitting an innovation to an organization, in which the innovation is shaped to suit routinized aspects of the organization and these routinized aspects are changed to accept the innovation. Adaptation is common to the change process in all areas, but more prevalent in education because of technological weaknesses and the diffuseness of organizational goals.[†] The technological weaknesses are inability to specify clearly either the configuration required to achieve certain outcomes, or the outcomes, and unpredictability of outcomes to overall goals. Thus, there are few incentives to use curriculum innovations in particular ways and, therefore, there is a necessity to engage in a continuing process of tryout, learning and modification to understand innovation and find most useful forms. In other areas where the technology is strong and incentives are clear and consistent among organizations, there is typically less adaptation--if not among individual users, at least over time for an individual user. In other words, strong technologies drive the incorporation process; weak technologies--like most curriculum innovations--are strongly interactive with the institutional setting.

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[*] Application of this methodology would show that few curriculum innovations are so new that they are not manifested somewhere in the education system. After the introduction of innovations through national development, the data might show increases, no change, or possibly even decreases in their incorporation.

[**] With this definition, "adoption" is the fact of use and not the decisionmaking process leading to use.

[***] Paul Berman and Milbrey McLaughlin, *Federal Programs Supporting Educational Change,* The Rand Corporation, R-1589/1-HEW, September 1974, p. 10.

[†] Ibid., pp. 9-10.

For the purposes of this study, four different levels of adaptation will be defined.[*] The *maintenance* level is when there is no adoption of an innovation, or use in a stable configuration--i.e., the use of the innovation has become routine. The *accommodation* level is when use of the innovation is dominated by the organization--i.e., the innovation is used in configurations not involving much displacement of organizational routines. We will say that when organizational routines are not displaced, there has not been much *structural change*. At this level, an innovation is used in minimal configurations and, consequently, there is not likely to be much effect on performance. A third level is when the innovation displaces organizational routines--i.e., there is structural change--and evidence of continuing reconfiguration to increase *performance effects*. These configurations may involve continuous, small refinements, or periodic restructuring as a result of overall assessments of performance and recognition of new opportunities. Refinement may involve redevelopment of the material embodiments of an innovation to meet an organization's needs.

Because of the similarities to our model of development, we will call this the *developmental* level of adaptation. The main similarities are structural change (in innovations for the school curriculum in development and in organizational routines in adaptation) and a performance-orientation. Research has shown that in the developmental mode of adaptation, there is characteristically a high level of deliberation within an organization in the form of frequent staff meetings and continuous planning,[**] which is another similarity to our model of development.

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[*] Gene T. Hall, "Levels of Use of an Innovation," *Journal of Teacher Education*, Vol. 26, No. 1, Spring 1975, pp. 52-56.

[**] Paul Berman and Milbrey McLaughlin, *Federal Programs Supporting Educational Change, Vol. IV: The Findings in Review*, The Rand Corporation, R-1589/4-HEW, 1976, p. 26.

Since the developmental level involves structural change, the changes in performance may possibly be more significant than with accommodation, but not necessarily because the configurations used may not be optimum for the innovation.[*] Researchers have long noted the importance of determining whether the "treatment is really implemented" in evaluating effects on performance. For purposes of assessing the effectiveness of national development without regard to implementation strategy, it is enough to show that the innovations produced effect performance in the ways intended without regard to actual usage configurations. Whether there are any policies for influencing the configurations that dominate in use to thereby improve performance is a matter that we will consider below.

A distinction between the maintenance and developmental levels has been previously noted in the research literature on the change process. From their case study of one school district, McKinney and Westbury[*] postulated that "maintenance" and "change" are two fundamentally different processes. Their main distinction was structural change. In a more comprehensive model, Berman and McLaughlin find a continuum in the innovative capabilities of local school districts from at one extreme maintenance, where among other characteristics bureaucratic and political goals "drive" delivery goals, and stability and uniformity predominate in service delivery to the other extreme of development, where delivery goals predominate political and bureaucratic goals, and there is service diversity.[**] From a review of research in state and local services, Yin postulates that there are two fundamentally different incorporation processes: one that he calls bureaucratic self interest and another that he calls service-oriented, production efficiency.[***]

These levels of adaptation need to be redefined somewhat for the different classes of institutions that we have distinguished to be more consistent with their functions. For user institutions, we will distinguish at the developmental level among *refinement/redevelopment* and

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[*] For example, in Gene T. Hall and Susan F. Luocks, "A Developmental Model for Determining Whether or Not the Treatment Really is Implemented," Research and Development Center for Teacher Education, University of Texas, January 1976, some data are given showing that student achievement can fall as higher levels of adaptation are reached.

[**] Paul Berman and Milbrey McLaughlin, The Rand Corporation, unpublished paper.

[***] Robert K. Yin, et al., *Technological Innovation,* The Rand Corporation,

renewal. Refinement and redevelopment is the process of modifying the configuration of an innovation to improve performance. Renewal is the process of periodically assessing performance in a deliberate and objective way and seeking major alternatives to the current configurations. For resource institutions, the maintenance level will be called *production*, which is continuing to supply resources without incorporating new innovations. Accommodation is the incorporation of an innovation but not in a configuration significantly displacing existing organization or technology.* The developmental level will simply be called *development*, signifying that innovations are incorporated in forms that result in significant restructuring and with a performance-orientation. For regulatory institutions, maintenance and accommodation are appropriate terms. For the developmental level, we will use the term *preformance* to stand for a regulatory process oriented to effects on ultimate beneficiaries and providing maximum flexibility to the institutions regulated consistent with regulatory objectives. For integrating institutions the maintenance level will be called *communication*, signifying that the institution simply serves as a conduit for information about an innovation. The developmental level will be called *leadership/redevelopment*, where the integrating institutions actively promote an innovation and may support redevelopment activities.

Institutionalization. A third property of these time series of the configurations of innovations is that persistence of use would be revealed by continued manifestation over time. The persisting configurations may be stable--i.e., the innovation is routinized--or continue to change. The configuration may or may not include organizational elements--i.e., incorporation in policies, organizational structures and support functions, etc. An innovation whose configurations contain many organizational elements will be said to be *institutionalized*, although not with the connotation that it will necessarily persist indefinitely. Innovation theory is not far enough advanced to specify whether there are any organizational elements where incorporation guarantees continuation for a long period of time. Organizational life is too uncertain for there not to be possibilities of idiosyncratic elements entering the picture to result in rejection of an innovation. However, a relationship between institutionalization and the likelihood of continuation in the near future probably exists.

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*For example, a publisher could accommodate the innovation of organizing subject matter around concepts simply by adding a few pages presenting these concepts in various places in a textbook. Or, the book could be entirely redone with the concepts providing the basic organization for presenting subject matter.

Policy Alternatives

In defining the incorporation of innovations according to their configurations in use, we are not making the distinctions commonly made among stages of the innovative process such as adoption, implementation, and institutionalization. We define incorporation by states of usage rather than processes and there is a continuum rather than a discrete number of possible states. Transitions from non-use to some configuration are adoptions; classes of configurations representing different levels of use can be distinguished and employed to trace usage over time.

Federal policy can be used to influence the levels of usage through intervention in different institutions. Certain instruments may be more effective in causing adoptions, while others may be more effective in causing higher levels of usage (the developmental mode or institutionalization). Some of these instruments are dissemination, teacher institutes, resource centers, teacher networks, and so forth.

We will say that incorporation is *controllable* by an instrument of federal policy if it can be shown that it produced predictably significant increases in levels of use. The effects may be either on adoption, or the levels of adaptation and institutionalization. We will say that incorporation is *idiosyncratic* if no instrument of federal policy can be shown to have predictably significant effects on levels of use.

We will call policy instruments intended to increase adoptions *adoption support* and instruments intended to increase the level of incorporation *implementation support*, as shown on the right hand side of Fig. II.1.

Other policy alternatives concern the relative emphasis in development on the alternative curriculum resources of innovations, products, and resource personnel. One alternative is to only produce innovations, as with the blue ribbon curriculum commissions in the past. Here, the product might be only a report on policy directions for the failure and recommendations to the schools. Another alternative is to convert these innovations into instructional materials for the classroom as was done in the NSF projects. A third alternative is to emphasize the production of resource personnel.

SELECTION ENVIRONMENT

In the previous section, we presented concepts for describing differences in the extent of incorporation of innovations by individual organizations inthe education system. These concepts were for distinguishing differences among organizations and over time in the incorporation of different curriculum innovations. From a national perspective, these concepts can be used to trace the patterns of incorporation of different curriculum innovations over time. Then the results could be compared to gain understanding of the forces that determine curriculum change and implications for federal policy. Some possible findings are that innovations in subject matter content (or certain kinds of subject matter content) are adopted more widely and rapidly than innovations in the mode of assignment and knowledge acquisition (which typically entail difficult changes in teacher behavior), or that some innovations result in more structural changes than others and in some institutions more than others. To understand the reasons for any differences found in the patterns of use of innovations, we need a framework of the different possible influences on the incorporation of an innovation.

Following Nelson and Winter, we use the concept of the *selection environment* for this purpose. The selection environment is the array of institutional and environmental factors explaining differences in the incorporation of innovations.* In general terms, the selection environment determines how the relative use of different innovations

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*Richard R. Nelson and Sidney G. Winter, "In Search of Useful Theory of Innovation," *Research Policy*, Vol. 6, January 1977, pp. 61-70.

changes over time in a system of institutions. The selection environment shapes the path negotiated by an innovation over time. Three components of the selection environment are: the *social/political environment,* what will be called *organizational regularities* within institutions, and their *innovative capacities.*

Social/Political Environment

The social/political environment is included because of its influences on the goal-setting and decisionmaking processes of education institutions and, therefore, the receptivity of those institutions to different innovations. Because of the public interest in education, the strong value conflicts inherent in the different conceptions of the social functions of schools, and the diffuseness of education technology, goal-setting and decisionmaking processes are highly political--both within education institutions and between those institutions and their constituencies.* Innovations that conflict with the dominant value preferences among these constituencies and internal staff stand much poorer chances of being incorporated than those that do not, and vice versa. And, the difficulty of determining the effectiveness of curriculum innovations often means that political factors dominate over evidence and reasoning in curriculum decisionmaking. Also, innovations may be used even though they are not demonstrably more effective, or not used even though evidence is available that they are more effective.

Saliency of Value Issues. Although values permeate all aspects of curriculum decisionmaking, the level of conflict varies greatly in intensity and predictability. In most curriculum decisionmaking, open conflict is rare and the underlying value conflicts obscure, elusive, and less prominant than other political aspects of the decisionmaking process. However, in certain curriculum areas, intense conflict is much more likely to be dominated by values reflecting philosophical differences. Examples in science are evolution and human reproduction. Innovations that conflict with strongly and widely held values will be called *value-centered.* The significance of these innovations is that less incorporation is likely and to occur through different processes than for all other innovations. Thus, the *saliency* of an innovation's value implications is an important feature of the selection environment.

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*Kurt and Walker, op cit., p. 489.

Politicization of Needs. Another important feature of the selection environment is when social issues become politicized demands on the education system for certain kinds of change, as in the late 1950s, when the need to improve science and mathematics education was strong. In such situations, educational institutions may be far more receptive to innovations in some way responsive to the demands being made than they ordinarily would. In effect, politicization of needs distorts the selection environment in favor of certain innovations, making them more likely than normally to be incorporated in some form. In these circumstances, incorporation occurs more because of the social/political environment than through ongoing institutional processes.

The issue for policy is how necessary an intense social/political environment is in relation to ongoing institutional processes for incorporation of curriculum innovations to occur--and especially with regard to innovations from national curriculum development. If the social/political environment is dominant, then the federal role in supporting national development should be limited to, at most, assisting the education system in *reacting* to crises. If institutional processes are dominant, then the federal role in supporting national development can possibly be more *deliberate* in assessing needs and proceeding with development.

Credibility. The incorporation of innovations is also influenced by the nature of evidence regarding the credibility of different innovations relied upon in curriculum decisionmaking processes. The different sources of evidence for the credibility of curriculum innovations (and products) are *testimony of successful use,* the *prestige* of persons advocating use (and particularly the reputation of the authors of curriculum products incorporating innovations), and *objective evidence* of performance. To the extent that testimony of successful use dominates over the other sources of evidence, the spread of innovations may be slowed. To the extent that prestige dominates, then the incorporation process is more political. Here, integrating institutions can be important through the sanctioning of innovations by the leadership of strong professional associations.

Dominance of performance information facilitates the spread of innovations not benefiting from a record of use or support from prestigious figures. In general, analysis of the sources of evidence important in the incorporation of innovations leads to consideration of the structure and character of the social systems in education that determine the configuration of the school curriculum. These social systems tend to be separated by subject areas. NSF's national curriculum projects injected the prestige of academic science into these social systems.

Organizational Regularities

Depending on the curriculum innovation, the pattern of incorporation can also be influenced by internal regularities of organizations in the education system. Innovations having *attributes* that conflict with these regularities are less likely to be adopted, and even if adopted, to be incorporated at lower levels of usage. These regularities fall into several categories: an organization's structure, its policies, budget resources, decisionmaking processes, and routinized behaviors of staff. The stronger a regularity is in an institution, the greater its effect is on the incorporation of an innovation.*

Organizational Structure. Three different types of regularities in organizational structure that we will consider are in the *distribution of authority, staff composition,* and *functional capabilities*. Innovations conflict with the distribution of authority in an institution when incorporation would entail shifts in status of leadership personnel. Similarly, incorporation can be limited by innovations that entail realignments in staff organization and composition. Functional capabilities can be a factor limiting incorporation when high levels of use would require adding new organizational functions. For the curriculum innovations that we will consider, these functions are mainly in material production and supply.

Policies. Policies are the norms and rules that have been established in an organization to guide decisionmaking and courses of action.** Among the many types of policies in education organizations, we will consider only those concerning priorities for the school curriculum or which conflict with particular attributes of innovations selected for analysis.

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*A regularity is stronger in an institution in proportion to the number of organizations conforming to it within that institution.

**Michael W. Kirst and Decker F. Walker, op cit.

Budget Resources. The financial budgets of organizations can affect the incorporation of innovations to the extent that the costs entailed in using an innovation exceed established budget levels or require allocations from separately administered cost categories. When cost categories are separately administered, users may have more difficulty gaining any approvals that are necessary than if only one approval is needed.

Decisionmaking Processes. Similarly, incorporation may be affected to the extent that certain attributes of innovations conflict with features of decisionmaking processes, causing the costs of gaining approval to be excessive. Such effects are mainly on adoption of innovations. The features of decisionmaking processes involved may be formal like the rules and regulations for the selection of instructional materials in state adoption boards, or informal like the traditional publishing practices of providing free samples of new materials to prospective customers.

Routinized Behaviors. Innovations that conflict with the behaviors that members of an organization customarily follow in performing their tasks may also limit incorporation. In user institutions, these regularities mainly include ingrained teaching behaviors.

Innovative Capacity

These organizational regularities are the routinized elements that may dominate innovations resulting in incorporation at the maintenance and accommodation levels, or that are changed by innovations if the developmental levels of incorporation are reached, as we discussed earlier in this chapter. Organizational theorists have postulated that organizations can have the general capacity of being able to reach the developmental level for most innovations incorporated and to retain this capability over long periods of time--i.e., that is a stable property.* Such organizations may or may not attempt more innovations but any innovations that they do attempt tend to be more fully incorporated.** The science innovation activity in one local school district that was described in Chapter I is an example of a moderate degree of incorporation at the developmental level that was achieved but apparently could not be sustained for more than a few years when operations apparently returned to the maintenance level. Organizations where achievement of the developmental level of incorporation is a stable property of innovative capacity will be said to have achieved *developmental change* capability.

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*Paul Berman and Milbrey McLaughlin, working paper, Rand Corporation.

**Too much innovation may overly disrupt the technical core of an organization causing deterioration of overall performance.

The levels of developmental change capability in organizations include the ones we distinguished for incorporation and in addition what we will call integrative capability; or capacity for *integration*. Integration is the capability of an organization to exapnd internal use of an innovation. For user institutions, integration is the capability to expand use to additional teachers and would be measured by the lateral spread of adoptions. In resource, integrating, and regulatory institutions, integration is the capability to reach out to user institutions through provision of adoption and implementation support. For publishers, this would be a capability to provide inservice training support as well as materials, and so forth. The various levels of innovative capacity for different institutions are shown in Fig. II.1.

The innovative capacity of organizations in the education system is an important component of the selection environment for two main reasons. First, the more organizations there are with developmental change capability, the greater the receptivity to innovations entailing substantial change in organizational regularities. Or said in another way, the more developmental capability there is in the education system the less important organizational regularities are as a component of the selection environment. Second, the more developmental change capability there is in the education system, the less need there would be for adoption and implementation support from external agencies to achieve higher levels of incorporation, assuming that incorporation is a controllable process in non developmental-level (maintenance mode) organizations.

A federal policy alternative is to intervene directly to increase organizational capacity to innovate instead of supporting the adoption and implementation of specific innovations. For this to be the preferred alternative, organizational development strategies have to be found that in some comparable way are more effective than adoption and implementation support in relation to cost. Analysis of this issue is beyond the scope of this report, although the implication for the appropriate federal role in supporting development and incorporation are fundamental. If organizational development strategies are more effective, then either national development should be supported independently of efforts to increase organizational capacity to innovate (i.e., with no support for adoption and implementation), or support should be provided only for organizational development and no national development on the grounds that national development is not worthwhile until the innovative capacity of educational institutions is increased.

An intermediate alternative would be to emphasize implementation support strategies for curriculum innovations that emphasize achieving higher levels of incorporation and later expanding to institutionalizing developmental capability. The strategy would be to use the context provided by the implementation of certain curriculum innovations for organizational learning about how to innovate. We will call this a strategy of *curriculum based organizational development*. Existing data are inadequate for comparison of this strategy to other strategies, but we can describe some specific models that have been followed in curriculum work.

Interinstitutional Relationships

Because of interdependencies among institutions in the education system, elements of the selection environment may be *interdependent* and *mutually reinforcing*. For example, schools of education are aware of organizational regularities in the schools and in the school curriculum, and therefore train teachers to fit into this environment so that they will have better chances for employment. Then the flow of these teachers into the schools reinforces the existing regularities in the schools and the school curriculum. Also, publishers must be aware of these regularities in deciding on innovations to incorporate in their products in order for these products to have a substantial market and for the publisher to have the financial resources to produce new products. Then, to the extent that publishers decide not to incorporate innovations conflicting with existing regularities, the flow of their products into the schools reinforces existing regularities. As we will show in later chapters, these interdependencies are numerous and complex among education institutions.

These interdependencies among institutions mean that the selection environment determining the course of incorporation of innovations also feeds back to the generation of curriculum resources by all other institutions in the education system.* Thus, the selection environment determines both the developmental capacity of the education system and incorporation. In this sense, development and incorporation are inseparable processes as far as the levels of functioning are concerned. The selection environment concept unifies our model of the curriculum change process.

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*Richard R. Nelson and Sidney G. Winter, op cit., p. 61.

The mutually reinforcing interinstitutional relationships in the education system maintain stability in the school curriculum and tend to produce convergence to uniformity in that curriculum. Thus, these interinstitutional relationships limit the capacity for development in the education system. National development substitutes for the lack of development capacity caused by these interinstitutional relationships that reinforce existing regularities in the education system.

INSTITUTIONAL CHANGE

Through introducing new curriculum resources into the education system, national development can change the selection environment. First-order change occurs to the extent that the innovations produced are institutionalized by institutions in the education system. This increases diversity in the selection environment. Second-order change occurs to the extent that national development effects the level of developmental change activity in education institutions--i.e., there are shifts from the maintenance to developmental levels of innovative activity in education institutions. This can occur through organizational learning from participating in nationally supported development and implementation activities, or as a consequence of the increased diversity in the education system. For example, increased diversity in the selection environment could bring pressure on policies in curriculum decisionmaking processes limiting choices to a few alternatives to increase the number of alternatives. Changes in this direction would shift innovative capacity in the direction of the developmental level. The possibility of increasing developmental capacity greatly expands the potential role of national development in improving education.

CURRICULUM POLICYMAKING INSTITUTIONS

In this section, we turn to descriptions of specific institutions in the education system--resource, regulating, and integrating institutions--and some of their influences on other institutions in the system. We omit user institutions because they are the local school districts.

Resource-Providing Institutions

There are four main resource providing institutions in the curriculum policy system: the publishing industry, colleges of teacher education, curriculum development centers, and categorical programs of state education agencies.

Publishing. The publishing industry is composed of three types of firms. One type is *textbook publishers* (within the industry, these are called el-hi publishers), whose main business is to supply printed materials to the schools. Another type is *scientific equipment suppliers,* who supply schools with laboratory equipment and supplies, mostly for science courses. The third type is *audio-visual publishers* (A-V), who supply schools with films and instructional programs organized around films or some other A-V media. In recent years, these distinctions among publishers by the type of product that they supply have begun to blur in that all firms are supplying more of all types of products.

Available data show that the publishing industry is highly concentrated. There are more than 150 firms[*] in el-hi publishing but only 7 of these firms had approximately 60 percent of total industry revenues in 1975 and 11 more firms had approximately 30 percent. In the same year, total sales to elementary and secondary schools were approximately $820 million.[**] Many of the smaller firms serve only regional areas or states. Although no data could be found, publishers say that there are four large firms in scientific equipment supply, and a large number of very small firms. There are more than 200 A-V firms[***] with 10 being dominant.[†] Total sales of A-V materials from all publishing firms to elementary and secondary schools was $200 million in 1975.[††]

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[*] *El-hi Textbooks in Print,* R. R. Bowker Company, New York, 1975, appendix.

[**] Association of American Publishers, "Industry Statistics," New York, 1975, Table T.1.

[***] Knowledge Industries Publications, Inc., "Educational Marketer," White Plains, New York, 1975.

[†] Conversation with the executive director of the Association of American Media Producers.

[††] "Survey of 1975 Educational Media Sales," Association of Media Producers," Washington, D.C., 1976, Tables 1 and 5a.

Teacher Education. Teacher education is an institution influencing the school curriculum mainly through providing trained teachers to the schools. Teachers can be influenced primarily in four different ways. First teachers may be socialized to the teaching styles of their professors, which carries over into classroom behavior. Second, teachers may gain knowledge of subject-matter content that affects curriculum choices made and the quality of their teaching. Third, teachers are exposed to specific curriculum materials during their training, and the familiarity and implicit sanctioning of these materials may carry over into preferences among alternative curricula in the classroom. A 1969 survey of 33 teacher education institutions found that 46 percent of all courses offered involve, to some extent, the "examination of instructional materials."* Publishers provide many of these materials free of charge and retain some of the professors as consultants. Fourth, Lortie has found that the time spent in practice teaching is an important influence on teachers. He adds another influence of the extended "apprenticeship" of observation throughout the teacher's own primary and secondary schooling.**

The pattern of teacher production is highly dispersed. Teachers are trained by about 1200 universities and colleges across the country, with each school producing only a small percent of the total graduates in each year. In 1974, the most graduates produced by any one school was .007 percent of the total of 300,000. Furthermore, most of the students in each school come from the local area and return to that area in their first teaching jobs. The patterns of training for specialist teachers are similarly dispersed. For example, of 400 schools of education that graduated mathematics specialist teachers in 1975, no one institution produced more than 75 of the total 2900 graduated. The implication for this study is that, in order to have a broad effect on the school curriculum, innovations must become incorporated in a relatively large number of places.

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*Lutian R. Wooton, "Technical Applications to Building Curriculum in the Field of Curriculum," in Edmund C. Short, *A Search for Valid Content for Curriculum Courses*, University of Toledo, ED040 129,

**Dan Lortie, *The School Teacher*, University of Chicago Press, Chicago, Illinois, 1966, pp. 55-81 and pp. 188-192.

***Robert Howe,

Curriculum Development Centers. A third resource-providing institution is curriculum development centers. These centers develop new instructional programs and then find a publisher to market the finished product as part of their product line. Some of these centers also provide inservice instruction in their programs.

One type of center is the seven Regional Education Laboratories, sponsored by the National Institute of Education (NIE). In 1975, these centers received about $20 million of NIE funding and some from other sources. A second type can be called independent centers in that they are free-standing and not tied to any particular federal agency, although some are highly dependent on federal grants and agency contracts. Two examples of these centers are the Educational Development Center (which grew out of PSSC), and BSCS, Inc. (which grew out of BSCS). There are also a number of centers in universities such as the education group in the Lawrence Hall of Science at the University of California at Berkeley, and the Social Studies Development Center at the University of Indiana. Some of these centers have semi-independent status within the university and others are no more than informal departmental or interdepartmental organizations.

State Education Agency Programs. There are a wide variety of state programs intended to support curriculum change. Included are programs supporting local innovative projects, training institutes and workshops, conferences and conventions, and stipends for university courses and summer school.* Funding may be targeted to specific categorical areas, such as reading or health education, or may be for general teaching and curriculum improvement. There are wide variations across states in the types of programs and levels of funding.

Regulating Institutions

The regulating institutions in the curriculum policy system are: state adoption boards, statewide testing programs, state-curriculum law, teacher certification, private standardized testing, college entrance requirements, and school accreditation.

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*Hannah N. Geffert et al., "State Legislation Affecting Staff Development in Public Education," Lawyer's Committee for Civil Rights under Law, Washington, D.C., March 1976.

State Adoption Boards. Twenty-two states, all in the South or West, have textbook adoption boards with legal authority to review and approve instructional materials used in the schools. The regulatory power of these boards is greatest in the states where the law requires that schools may not use other than approved textbooks and there are only a few alternatives on the state-approved list in each subject matter area. In the past, some states have provided only one alternative. In other states, the regulatory power of the board is less because the approved list may be longer, or schools may not be required to use approved lists. However, in most of these states, there is a financial incentive to use adoption board-approved books because they are provided free of charge. In a few states, the board-approved list is only advisory or schools may easily gain approval of their own choices. Some state adoption boards are directly accountable to the state legislature, while others are part of the state education agency.

Statewide Testing Programs. Many state legislatures have passed laws requiring statewide testing of student performance at either or both the elementary and secondary levels. The regulatory power of these tests depends on the subject matter areas covered and how the results are used. One major influence is when admission to various institutions in the state university system is contingent on tests of high school performance, as is the case in many areas. Another influence is when the type of diploma that high school students receive is contingent upon their test performance. In an increasing number of states, students are being required to achieve minimum performance on a standardized test in order to graduate from elementary school to high school or to leave high school. Finally, the results of state testing programs may be used to rank school or school district performance, bringing public pressure on the schools to emphasize the kinds of instruction that will raise test scores. One of the most widely known state testing programs is the New York State Regents Examination, which is used for admittance to the state university system and determines the type of diploma that a student receives. Separate examinations are given for almost every academic subject matter area of the school curriculum.

State Curriculum Law. In addition to establishing testing programs, state legislatures have been very active in passing laws to directly regulate the content of the school curriculum through mandating that certain courses be offered and taken, or through specifying amounts of time that must be devoted to certain subject matter areas.* Some legislatures have even passed laws that certain topics be covered within subject matter areas and in certain ways. For example, in California, the legislature has written requirements for the content of some social studies courses into state statutes.

Teacher Certification. Another state-level regulating influence on the school curriculum is teacher certification. Teacher certification influences the curriculum priorities and degree requirements of teacher education institutions and, through this, teacher competencies, and hence the school curriculum. One example is that elementary teachers might be far more inclined and competent to teach science in the elementary school if certification requirements were higher in this subject matter area than they are.

Private Standardizing Testing. Although we could not find any substantial studies of the issue, the private industry involved in developing and marketing standardized tests is a major institution in the education system that may have a strong influence on the school curriculum through use in statewide testing programs and more general use by schools. At the high school level, the principal organizations are the Educational Testing Service (ETS, which publishes the College Entrance Examination Board battery of tests, the National Merit Scholarship exams, and the Advanced Placement tests), and the American College Testing Program. At the elementary level, there are several firms in the market, many owned by textbook publishing firms.

Standardized testing influences the school curriculum through the subject matter topics emphasized in tests and the form of questions asked (e.g., fact recall or reasoning skills). The national curriculum projects in high school science thought the testing industry was enough of an influence on the curriculum to bring pressure to bear on the College Entrance Examination Board, which is the major publisher of subject matter area tests at the secondary level, to develop special tests for new curricula that were being developed. CEEB initially resisted issuing special tests on the grounds that their policies were against leading curriculum change in a subject area, but did so for a number of years after the national curriculum projects were released.[*]

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*Tyll van Geel, "Authority to Control the School Curriculum: An Assessment of Rights in Conflict," University of Rochester, Rochester, New York, unpublished manuscript, to be published as a book.

College Entrance Requirements. University entrance requirements concerning how many semester hours high school students must have taken of certain subjects also exert a regulating influence on the high school curriculum. For example, to the extent that foreign languages are required, high schools must offer and college-bound students will take foreign languages. In science, many universities prefer "solid" training in the separate disciplines of physics, chemistry, and biology to general science courses as preparation for undergraduate work and may not approve "integrated" science courses.

School Accreditation. Another regulating influence on the curriculum is school accreditation. There are six regional associations that accredit high schools and colleges, plus the National Council for Accreditation of Teacher Education, which accredits teacher education institutions. Accreditation influences curriculum through detailed standards that these associations have developed, with which schools must comply to be accredited. For high schools, these criteria concern course offerings, administrative procedures, and physical facilities. The detail of these standards for high schools suggests that the influence of accreditation on the curriculum may be great, but the actual effect has not been empirically studied.[**]

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[*] Arnold B. Grobman, op. cit., pp. 133-135.

[**] For different views, see Fredrick M. Wirt and Michael W. Kirst, *The Political Web of American Schools*, Little, Brown and Company, Boston, Massachusetts, 1972, p. 208; Koerner, op. cit., p. 54; and O. W. Markley, "The Normative Structure of Knowledge Production and Utilization in Education," Stanford Research Institute, Interim Report, Contract #NIE-C-74-0133, December 1974, pp. B50-B55.

Integrating Institutions

Finally, there are four integrating institutions in the curriculum policy system: professional associations, scientific societies, interest groups, and teacher networks.

Professional Associations. For almost every resource-providing and regulating institution discussed, there are one or more cross-cutting professional associations. These include,[*] but are not limited to:

- School Division of the Association of American Publishers
- Association of American Media Publishers
- American Association of Colleges for Teacher Education
- Association for Supervision and Curriculum Development
- National Science Supervisors Association
- National Association of State Textbook Administrators
- National Association of State Directors of Teacher Education and Certification
- National Council of Teachers of Mathematics
- National Science Teachers Association
- National Association of Biology Teachers
- American Association of Physics Teachers

Most of these organizations have memberships from predominantly one type of organization influencing the curriculum, but others are mixed. For example, the membership of the School Division of the Association of American Publishers is almost without exception from el-hi publishing houses, while the members of the National Council of Teachers of Mathematics are mostly elementary and high school teachers but with some professors of mathematics education.

Professional associations influence the curriculum in a variety of ways. Periodic national and regional conventions provide an opportunity for members to trade news and information and to hear papers presented. Most of the associations also publish a journal of news, positions on issues, and technical articles. Organizations such as the School Division of the American Association of Publishers and the National Association of State Textbook Administrators meet on a regular basis to discuss issues of common concern.

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[*] Craig Colgate (ed.), "National Trade and Professional Associations of the United States and Canada and Labor Unions," Columbia Books, Inc., Washington, D.C., 1976.

The influence of these professional associations on the school curriculum has not been well studied, but there are signs that at least some of them are important. Publishers know these organizations well and attend all the national and many of the regional meetings to re-establish contacts and "get a feel" for the way the curriculum is going. Changes in teacher certification have emerged from interactions of the American Association of Colleges for Teacher Education, the National Association of State Directors of Teacher Education and Certification, and committees of the National Education Association and the Council of Chief State School Officers.* The National Council of Teachers of Mathematics (NCTM) is one of the strongest associations and was heavily involved in forming the School Mathematics Study Group (SMSG) national curriculum project, had leading members who sat on the SMSG advisory committee and participated in the curriculum writing groups, and was very active in disseminating news and information about the "New Math" through its conferences and newsletters.** SMSG utilized the social structure of NCTM to a much greater degree than any other NSF national curriculum project in mathematics.

Scientific Societies. Scientific societies constitute another integrating process similar to the professional associations. Prominent among these are the Education Section and Science Education Division of the American Association for the Advancement of Science, and several research societies, such as the National Association for Research in Science Teaching. Many of NSF's national curriculum projects were supported through these scientific societies.

Teacher Networks. Third, there are a few informal networks of teachers that exist in the education system that are an influence on the school curriculum. These networks typically have a center with a director and a small staff that serves as a node of communications among the participating teachers and a place where they can come to learn from each other and the staff about teaching and curriculum. Usually, the sharing and making of materials are important activities. Most of these centers are independent from formal institutions in the education system and draw membership from a broad geographical area. Many of these networks have grown out of national curriculum projects.[*] One example is the Federation for Unified Science Education, which is a network of teachers interested in the integration of science curriculum. In total, there are probably about 100 to 200 of these networks currently in existence.[**]

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*T. M. Stinnett, op. cit., p. 1.

**William G. Wooten, op cit., p. 10 and p. 15.

Interest Groups. Finally, we include interest groups as an integrating institution. Interest groups at the local level include the parent-teachers associations; business/professional organizations, such as chambers of commerce; the League of Women Voters; ad hoc groups; and so forth.[***] At the national level, there are many other groups.[†] One of the most prominent is the Council on Basic Education (CBE), another is the Committee on Intellectual Freedom of the American Library Association, which publishes a newsletter on events concerning text and library book controversies and provides support to librarian and teacher members involved in disputes.

FEDERAL INTERVENTION

The policy issues concerning national development that have been introduced in this chapter need to be reviewed to provide direction for the analysis that follows in the remaining chapters. In Chapter VII, we will return to these policy issues in drawing our conclusions.

The first policy issue concerns the need for national development in improving education. From our conceptual framework, the function of curriculum development is converting knowledge into curriculum resources for meeting social needs. Development enables the education system to convert knowledge into curriculum resources as it is produced, to anticipate needs, and to respond to diversity. Therefore, national development is justified to the extent that capacity for performing this function is lacking in the education system and that the innovations produced are incorporated. To assess the need for national development, we will assess the developmental capacity of selected institutions in the education system to the extent that evidence is available and the ways in which this capacity is limited by interinstitutional relationships. We will also summarize existing evidence on uniformity in the school curriculum and describe the kinds of educational needs addressed by innovations in selected NSF projects as a means of illustrating the kinds of needs for which development has previously not been undertaken in the education system. Lastly, the model for the incorporation of curriculum innovations will be applied to selected NSF projects to assess the effectiveness of national development in changing education. An important class of effects will be any institutional changes resulting in increased developmental capacity of the education system.

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[*] Kathleen Devaney and Lorraine Thorn, *Exploring Teacher Centers*, Far West Laboratory for Educational Research and Development, San Francisco, California, 1975.

[**] Conversation with Lorraine Thorn of the Far West Laboratory for Educational Research and Development. Far West is maintaining a communication network among teacher centers.

[***] The PTA, the League, and the Chamber of Commerce also have national organizations.

[†] Stephen K. Bailey, *Education Interest Groups in the Nation's Capital*, American Council on Education, Washington, D.C., 1975.

All other policy issues that we considered concern federal strategy in supporting national development.

One is whether national development should be limited to use in temporarily assisting the education system in responding to urgent national needs, or supported on a continuing basis. Whether national development should be mainly supported in response to crises or continuously will depend on the results from assessing the importance to incorporation of the social/political environment. For a continuous role, criteria are needed for selecting subject areas.

Second, there are a series of alternatives for federal support of incorporation. Federal policy can be to support adoption, implementation, curriculum-based organizational development, or organizational development. The last two emphasize building developmental capacity in the education system, while the first two are innovation-specific. The central issues are how important these different forms of support are to incorporation and whether this support should be directed only to schools, only to intermediate institutions, or to both. If adoptions are strongly controllable, then adoption support is necessary; but if adoptions are idiosyncratic, no adoption support should be provided; and so forth. Similarly, if incorporation is idiosyncratic for all these forms of support, consideration should be given to emphasizing organizational development strategies.

A third set of policy alternatives concerns the importance of different curriculum resources to incorporation and therefore the relative emphases that should be placed on them during development. The alternatives are an emphasis on resource personnel over products and either finished, preliminary, or prototype versions of materials.

At the extremes of these alternatives are two distinct strategies for supporting national development. One is the *programmatic* extreme of support mainly in response to crises, with the objective of developing curriculum designs to be incorporated intact in the school curriculum, and with emphases on finished materials and school-level adoption and implementation support. Another is the *resource*-oriented extreme of continuing programs of national development, with the goal of redevelopment by users of resources produced to meet their own needs, and with emphases on unfinished materials and capacity building in intermediate institutions and in the schools. The latter is directed toward creating technological environments conducive to curriculum and organizational change.

STUDY METHODOLOGY (to be added)

The complexity of this conceptual framework and the large number of NSF projects requires that we must be selective.

1. Limit to natural science, reject mathematics, social science, other subject areas. Emphasis on secondary biology, elementary science.
2. Limit to publishers, state adoption boards, schools.

Limited project resources requires use of available research and data. Different analyses require different data methodologies. Methodologies will be presented with each analysis.

REPORT PLAN

Chapter III: CURRICULUM RESOURCES PRODUCED
Chapter IV: SELECTION ENVIRONMENT
Chapter V: FEDERAL SUPPORT FOR INCORPORATION
Chapter VI: INCORPORATION IN THE PUBLISHING INDUSTRY
Chapter VII: INSTITUTIONAL CHANGE
Chapter VIII: CONCLUSIONS

CHAPTER III

CONTRIBUTIONS TO EDUCATION

The purpose of this chapter is to describe the curriculum innovations in a selected number of NSF national curriculum projects and to summarize the existing evidence regarding the classroom effectiveness of the curricula produced. The results provide motivation for analyzing problems in introducing these innovations into the school curriculum in later chapters.

In selecting the sample of projects to describe, we used three criteria. First, we wanted the projects selected to include at least one project at each grade level. Second, we wanted the initial starting dates of the projects selected to be distributed over the time period since the first projects were supported with an emphasis on the more recent projects to indicate the evolution in project goals and methods. Third, we wanted the sample to include at least one innovation in each of the components of the school curriculum. In diagramming the projects by year of initiation and grade level, as shown in Table 9, we found certain clusters of projects that partially determined how the sample should be drawn. The first cluster is the initial group of high school science projects, starting in the late 1950s, which are the most well-known of all the projects that NSF has supported. Because of our decision to concentrate on biology (which was discussed in the last section of Chapter I), we chose the Biological Sciences Curriculum Study (BSCS) from this group. The high degree of similarity in the curriculum philosophies and methods of these early high school projects makes BSCS a good prototype of the entire group. The second cluster is the initial round of elementary science projects starting in the early 1960s. These projects differ much more from each other in their philosophies and methods than the early high school projects. We chose the Elementary Science Study from this group. The third cluster is the second round of high school science projects starting in the mid-1960s. From this group, we chose Technology and the Man-Made World (TMMW) because it is an entirely new course, not involving subject matter from any of the traditional science disciplines. Finally, for an intermediate level project, we chose the Human Sciences Program (HSP) because of its continuities to BSCS; and, at the elementary level, the Unified Science and Mathematics for the Elementary School Project (USMES) because of its continuities to ESS.

INNOVATIONS IN THE SCIENCE CURRICULUM PROJECTS

The projects selected will be described through first presenting the basic project rationale and then listing all of the key ideas for improving the school science curriculum advanced during the course of curriculum development. The information in these descriptions was obtained from project literature and interviews with project directors and staff.

Biological Sciences Curriculum Study

As one of the early high school science projects, the BSCS project was formed in the intense climate of need to reform education that was a product of mainly the public reaction to the progressive and "life-adjustment" movements of the previous years and national concern that the poor quality of school science and mathematics was severely restricting the production of scientific and engineering manpower essential to national security in an era of rapid growth in science and technology. The biological scientists who formed BSCS, similarly to the scientists who formed the other early high school curriculum projects, thought that significant improvements could be made in the biology curriculum. The scientists generally thought that the biology being presented was too fact oriented, fragmented, and outdated in relation to the modern state of the discipline. The scientists thought that biology could be presented in a way that would make it more interesting to students and better prepare them for a scientific career if they chose to be scientists or, if they did not, to better understand the nature of science and its relationship ship to society. The scientists wanted to make biology a subject that would stimulate students' innate curiosity about living things and convey the human side of scientific endeavor.*

BSCS advanced four main ideas for improving high school biology which were incorporated in a variety of curriculum resources: Three basal textbooks (the so-called Yellow, Blue, and Green versions), the Biology Teachers' Handbook, a Laboratory Block Program, an activity-oriented program for the academically less successful (Patterns and Processes), and a rich variety of supplementary materials (phamplets, films, film strips, slides, and so forth).

First, the BSCS developers maintained that the subject matter content of existing courses was outdated and far too narrow in relation to the modern state of the discipline. The subject matter in existing courses reflected the old form of the discipline when it was highly compartmentalized into fields according to major categories of living organisms (e.g., human physiology, zoology, botany, etc.), and biologists' major tasks were to observe and classify organisms, dissect them, and describe their anatomical features and physiological functions. As a result, existing courses overemphasized the organ-tissue levels of biological organization and failed to sufficiently include the molecular,

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*Bentley Glass, "A New High School Biology Prc
Scientist, Vol. 49, 1961, p. 525, and Paul DeHart I
in Secondary School Science, Rand McNally, Chicago,

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cellular, population, community, and world biome levels of organization that have been the areas of most active inquiry and scientific advance in recent years. The new knowledge produced in these areas has unified biological science and conveys a much richer meaning of life to comtemporary scientists. Furthermore, the BSCS developers "unanimously agreed that appropriate scientific treatment (should) be accorded to such controversial subjects as...the nature of individual and social differences, sex and reproduction in the human species, the problems of population growth and control," and, as will be discussed below, organic evolution.[*] Thus, the idea was to shift the content emphasis of high school biology from mainly the otgan-tissue level of biological otganization to a more balanced treatment of all levels, and to include socially significant topics to which knowledge from biological science is relevant.

Second, the NSCS develoeprs thought that the accretive process through which topics had been introduced into the high school biology curriculum over the years had resulted in text materials and instruction having a "patchwork quality" that did not allow students to generalize and apply what they learned. The idea advanced was to organize subject matter around a few conceptual themes derived from the overarching theoretical structure of biology. The themes chosen were:[**]

- Change of living things through time: evolution
  - diversity and unity in the pattern in living things
  - genetic continuity of life
- Complementarity of organism and environment

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[*] Bentley Glass, op. cit.

[**] Joseph J. Schwab, *Biology Teacher's Handbook*, John Wiley and Sons, New York, 1964, p. 31.

  - biological roots of behavior
- o Complementarity of structure and function
- o Regulation and homeostatis: preservation of life in the face of change.

It was believed that structuring content in this way would shift learning to a high conceptual level, thereby making the study of biology more meaningful to students through showing them the power of scientific knowledge to unify and explain diverse phenomena, as well as enabling them to learn more on their own from nature and be more capable of integrating future scientific and technical developments into their thinking. It was seen that these capabilities would deepen students' understanding of science and its relationship to society, and result in them making more informed decisions as citizens.

Third, the usual presentation of biological subject matter as a "rhetoric of conclusions"--i.e., a series of fixed and unalterable truths to be taken literally--with separate and superficial treatment of the scientific method as being simply the steps of hypothesis generation, data collection, and verification was seen to convey a false and furthermore sterile image of the process of scientific inquiry. In BSCS, the idea was advanced of instead presenting subject matter in a "narrative of enquiry."[*] In a narrative of enquiry, subject matter facts are presented in a way that reveals the true nature of the search for scientific knowledge and not just the facts that are found. Subject matter is used to show the complex relationship between theory and facts in constructing knowledge, the functions of theory and data in occasionally leading to substantial revision of theory, as well as the selectivity of theory in providing interpretations of data and in application to real phenomena.[*] In text materials, the presentation of biology as a narrative of enquiry involves showing:

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[*] Ibid., p. 40.

> "...the conclusions of science in the framework of the way they arose and were tested. This (involves telling students) about the problems posed and the experiments performed, to indicate the data thus found, and to follow the interpretation by which these data were converted into scientific knowledge."[**]

The method also involves raising the "doubts and incompleteness of science and indicating the possibility that through the advance of enquiry, scientific knowledge can change."[***] In application to teaching, the enquiry idea implies that the questions asked in a classroom should not be "... primarily to discover whether the student knows the answer but to exemplify to the student the sorts of questions that he must ask of the material he studies and how to find answers."[†] Teachers should ask questions that evoke alternative answers and set them in juxtaposition in ways that send students in search of evidence for answers in order to teach the lessons that "many questions have no 'right answer' but only probable answers,...that there is room for interpreting data,...that the aim of criticism and defense of alternative answers is not to 'win the argument' but to find the most defensible solution to the problem."[††] It was believed that through presenting subject matter in this way, students would find biology more interesting, be encouraged and better prepared to pursue scientific careers, and, if they did not, to be more literate as citizens of the potential and limits of scientific enterprise.

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[*] Joseph J. Schwab, *The Teaching of Science as Enquiry,* Harvard Press, Cambridge, 1966.

[**] Evelyn Klinckman, *Biology Teachers' Handbook,* John Wiley, New York, 1970, p. 23.

[***] Ibid.,

[†] Joseph J. Schwab, op. cit., p. 67.

[††] Ibid., p. 67-68.

Fourth, the BSCS advocated a substantial increase in laboratory work and redirection from demonstration of conclusions previously learned in class to illustration of problem situations prior to classroom discussion. The laboratory is intended to "display the phenomena which give rise to problems, the circumstances surrounding the acquisition of data for solving these problems, and the difficulties of working with and among these circumstances."* Instead of students engaging in pasting leaves into notebooks and dissecting frogs, genuine investigations of biological phenomenon would be undertaken. New laboratory equipment was required: living organisms instead of dead specimens, and the addition of refrigerators, microscopes, running water, and other scientific equipment and supplies.

Elementary Science Study

In 1960, the American Association for the Advancement of Science conducted a series of regional conferences across the country to assess needs for improvement in elementary science education. The overall conclusion of the conference was that elementary science needed to be improved because "future citizens must be generally cognizant of the nature of science and its role in human existence."** Other conclusions were that the improvement effort would require changes in both course materials and classroom instruction, and that a diversity of approaches should be pursued. Several curriculum projects were started, five funded by the NSF. One of these was the Elementary Science Study, which was conducted by Educational Services Incorporated (now the Education Development Center).

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*Ibid., p. 54.

**"Science Teaching in Elementary and Junior High Schools," *Science*, Vol. 133, June 23, 1961, p. 2020.

The scientists who formed ESS, most of whom had been leaders in PSSC, started only with the general idea, drawn from their previous curriculum experience, that the major change needed in elementary science was to involve children in actually doing science instead of just being told its conclusions or reading about it. They believed that the way elementary science was being taught from textbooks as a body of knowledge and a tried and true methodology in a rote manner to whole classes was wrong. But beyond this general criticism, the scientists could not clearly specify what approach should be taken. In one of the early planning conferences, a teacher who was involved convinced the scientists that more teachers should be added to the staff and that all the developers, and especially the scientists, should be intensely involved with children at early and all subsequent stages of developing each curriculum unit instead of the "write first and try later" procedure that had been followed in the earlier high school projects. This mode of developing curriculum through scientists and teachers working together directly with children turned out to be highly productive and produced a new and much more open approach to elementary science. In working together with children, the scientists and the teachers found that they shared attitudes about children and strategies for teaching them science.*

The goal of the ESS curriculum is developing an understanding of science in children that will--in a phrase that the developers borrowed from John Dewey--"sink into the subsoil of the mind." The intent was to naturalize and humanize science for bridging the gap between the science and other ways

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*Emily Romney and Mary Jane Neudorfer, *The Elementary Science Study--A History"* Education Development Center, Newton, Massachusetts, 1973, p. 17.

of life,[*] a task that ESS did not see that it alone could not accomplish, but which they thought should be pursued. While the curriculum for schieving this goal is difficult to describe, four ideas can be identified.

First, the usual student books and teachers' guides in conventional elementary science programs are replaced with a vast array of natural materials and other learning resources. The finished curriculum has 56 different teachers' guides, 40 kits of materials containing over 4000 parts, 56 film loops and films, and 11 student booklets instead of the usual seven student books and separate teachers' guides in conventional K-6 elementary science programs. The reason for the materials was to provide a diversity of sensori stimuli that the developers thought were essential for early learning. They thought that before conceptual learning could occur, a wealth of actual experience with real things had to be laid down in memory. Presenting the derived and abstract logic of science in a verbal form before concrete experience is gained through manipulating things, perceiving effects, and realizing complexity and ambiguity of phenomena was seen as inimical to later learning.[**]

A second feature of ESS was that learning concepts and facts were seen as far less important to gaining understanding of science at the elementary school level than providing children with opportunities for exploration. Exploration means giving children the change to touch, to observe, to construct, to probe, and to see what happens, withoug being directed by the teacher. This mode of learning was seen to be consistent with the way children learn in their years preceding school, when they are highly successful in achieving complex cognitive skills. In their early years, children learn through imitating their parents and others with whom they come in contact, trying out operations in all sorts of contexts and making mistakes, practicing what seems to work, and in other informal ways that the developers saw should be duplicated in the classroom instead of substituting, as in most elementary schools, formal modes of learning.

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[*] David Hawkins, "The Informed Vision: An Essay on Science Education," *Daedalus*, Summer 1965, p. 545.

[**] Phillip A. Morrison, *Experimenters in the Classroom*, unpublished manuscript, 1964, Chapter III.

Getting students to ask the right questions of materials and pursue answers was seen as more important than what answers were found. For example, upon first seeing the caterpillar eggs in an ESS unit on the life-cycle of butterflies, a student led to exclaim, "Why, those things look like seeds!" and then to ask, "How can one tell the difference between eggs and seeds?" was the kind of outcome that was sought. Then the child might want to or be encouraged to think of ways to determine whether an object was an egg or a seed. Will color comparisons do, or weighing, or planting, or what? Another example is from a unit on optics where students are provided with a collection of light sources, lenses, mirrors, prisms, and containers of fluids and the objective is to learn something about the properties of light reflected from surfaces and passing through solids and liquids. After exploring this apparatus for a while, some student might discover that properties of light are much easier to observe if the classroom is darkened. It was thought that there was much more insight into the nature and limits of science in this realization (i.e., ability to reduce background noise determines how far you can get scientifically) than being directly told conclusions about the properties of light. It was believed that children would much more deeply perceive the significance of these insights (even if they couldn't verbalize them) through their own work, possibly requiring a long period of time, than if given the insights by the teachers. Reaching the point where children want to investigate what happens to the butterfly if the caterpillar is feed something different, or if the cocoon is warmed is what the developers wanted to occur in the classroom. The trick in developing materials was to find things and lists of exercises that would "click" in this sense with the children.

A third feature of ESS, was that in designing units, the develoeprs sought to find materials and activities that exhibit scientific principles as natural phenomena within the realm of children's experiences. For example, in the Daytime Astronomy unit, the general objectives are to learn about the relative motions of the earth, moon, and sun, but instead of presenting pictures of the orbits of the planets in the solar system, as in most conventional elementary science programs, children engage in activities like observing and measuring changes over days and months in the direction and lengths of shadows cast by the sun from a stick propped in the ground, or in the shadings and positions of the daylight moon, or in patterns reflected on the blackboard from sunlight bouncing off a mirror laid on the window sill. Light bulbs and globes are also available to explore different reasons for any phenomina observed. The idea is to find activities that will deepen and extend children's understanding of their natural environment through building on expereinces that they have already had.

A fourth idea in ESS was that instructional materials should be multi-programmed, in the sense that each unit have the greatest possible variety and flexibility in ordering of topics to allow children to find many different ways into and out of a subject and into other subjects.* For example, the children who condered from exploring the life cycle of butterflies, how to tell the difference between eggs and seeds might be more

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*David Hawkins, "Messing About in Science," *The ESS Reader,* Education Development Center, Newton, Massachusetts, 1970, pp. 37-44.

interested in learning about the growth of seeds than working further on butterflies. There is a unit on growing seeds in ESS that the teacher can turn to as a resource. Or, the film included in the "Butterflies" unit showing the microscopic structure of caterpillar eggs and how they develop (which is often of great interest to children after they have seen what the eggs are for) might stimulate some children into wanting to find out the microscopic structure of other things. These students could be given the microscopes in ESS and the unit on Cells or they might want to investigate materials of their own choosing. Or, other students might want to see if the bread molds that they investigated in a previous unit also have a life cycle.

The role of the teacher in the curriculum in encouraging students to pursue their interests, assisting them in seeing the significance of the consequences of their choices, and guiding them into new areas when they are stalled.

Fourth, as easily guessed from this discussion, the ESS curriculum was highly flexible. Each unit can be covered in any depth, making it possible to use them at different grade levels and even used again at higher grade levels when the children are ready to go further with any investigation. Most of the materials can be made or assembled by the teacher and do not have to be purchased. Teachers may find that the pattern of activities in the units and the discoveries of their children suggest many other activities for which materials can be developed. ESS lays down a pattern but it is an unfinished curriculum.

The three remaining NSF curricula that we selected--Technology and the Man-Made World, Human Sciences, and Unified Mathematics and Science for the Elementary School will not be described in as much detail as BSCS and ESS. After stating the general curriculum objective, only brief descriptions of the key innovations are given.

Technology and the Man-Made World

By the mid-1960s, the problems of poor quality in science in the high school curriculum that dominated in the 1950s, began to be overtaken by concerns heightened by falling enrollments in physics and chemistry, that coursework in science should be more directly related to students' interests and to issues of the role of science and technology in society. These concerns led to the second round of NSF high school science projects, and one of these is Technology and the Man-Made World (TMMW).

The goal of TMMW is to help students in forming a greater understanding about the nature of the interactions between science, technology, and society and the potential role of science and technology in solving social problems. The course is intended for college-bound students who do not wish to take physics and chemistry.

There are four main ideas in TMMW. First, the intent of the course is primarily to assist students in gaining understanding and forming attitudes, and not explicitly to teach them subject matter content. Second, the technique of the course is to employ examples of technology in social settings to communicate basic concepts to students that will help them form understanding and attitudes. In other words, the technique of the course is to teach concepts through extracting subject matter from examples that are familiar to students. As a result, subject matter content is not treated in as orderly and systematic way as in most science curricula. Third, the concepts incorporated in the course are entirely new for the high school curriculum in that they are from engineering and not science. These concepts are decisionmaking and optimization (i.e., making tradeoffs), modeling, systems, feedback, stability, and machine computation. Fourth, many laboratory acitivites are organized around a computer.

Human Sciences Program

In 1966, BSCS submitted a proposal to the NSF for a project to develop guidelines for an intermediate grade level life science course to complement the new elementary and high school courses that were becoming available from other national curriculum projects. Through a series of conferences and visits to schools across the country, a conclusion was reached that the course should "center on and emanate from" the cognitive abilities, and the personal and social interests of the individual student.[*] This orientation was seen as particularly important because of the rapid shifts in physical, intellectual, and social development that occur during early adolescence which existing curricula do not directly support. A need was also seen to continue the emphasis of the new elementary science programs on concrete experiences and teacher and student role definitions that actively engage students in learning how to learn.* To accomplish these objectives, subject matter from both the natural and social sciences would be required.

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[*] George M. Clark, *Life Sciences in the Middle School,* Biological Sciences Curriculum Study, Special Publication No. 7, 1969, p. 4.

A grant to produce an intermediate grade curriculum along these lines and to be called the Human Sciences Program was awarded by NSF in 1970. The curriculum that has been developed employs four main ideas.

First, the subject matter is structured by a three-level hierarchy of problem-oriented questions that have been found to be of interest to students rather than concepts from the disciplines. Subject matter is selected from the disciplines as appropriate to addressing each of the questions in the hierarchy. For any particular question, the relevant subject matter may be from any single or several scientific disciplines. The most general questions define areas of study that are called "modules" to be covered in five to seven weeks of class time. These questions are motivated by one or another of three overarching themes of: continuity and change: competition, accommodation, and cooperation; and equality and inequality. Examples of module level questions are: How are human beings similar and different, and how do organisms develop?

The next lower level of questions define "problem areas" of study within a module. For example, in the module on development of organisms some problem areas are development in humans, plants, and animals, At the lowest level of the hierarchy, each question defines an "activity" of which there are typically 15 to 20 per molude. Most of these activities are based on a topic from a single scientific discipline.

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*Ibid., and James T. Robinson, "A Theoretical Framework for Interdisciplinary Science Curriula for Early Adolescents: The BSCS Human Sciences Program," memo, BSCS, P.O. Box 930, Boulder, Colorado, p. 12.

The formulation of specific problem areas and activity was guided by four "generic questions" that were synthesized from interviews with a large number of intermediate level students. These four questions were: What is normal (and especially am I normal?), why do living things act as they do (and especially why do adults act as they do?), why do things change, and what determines who gets what? As an example of how these generic questions were used, the intent of some activities in the module on similarities and differences in human beings is to show that large differences are normal.

Second, the activities in each module are designed to accommodate the large differences in cognitive, and social development characteristic of intermediate grade students. This is done through having a large number of activities in each problem area and dividing each activity into three levels, corresponding to different levels of cognitive and social development. Level I activities provide concrete experiences in data gathering, reading, working with media, observing, constructing, and conducting various direct experience tasks. Level II activities involve students in the higher order activities of data reduction, speculation, display of data, making value judgments, and interpreting and explaining data. Level III activities include the development of hypotheses from data obtained from earlier levels and applications in new situations. Some activities are more personally and socially oriented, and others are more oriented to the natural world.

Although activities in the curriculum span the full range of cognitive stages from concrete to formal operations, the main target of the curriculum as a whole is to facilitate thinking at the level of "complexes" of specific relationships rather than overarching systems of scientific concepts.

Thinking in terms of complexes has been defined by Vygotsky as a stage where objects and phenomena in the natural environment are grouped by subjective impressions or bonds that actually exist, as distinct from the stage of formal thought where objects and phenomena are grouped according to a system of super-and subordinate concepts. Citing Piaget's findings that early adolescents are only Beginning to develop the capability for formal abstract thought, the developers believe that an emphasis on concept acquitision would have been inappropriate for the intermediate grades. Thus, the goal of the Human Sciences Program is only to provide students with a so called "data bank" of experiences that will facilitate their making the transition to formal thought in the high school grades.

In the area of social development, the main targets of the Human Sciences Program are to assist students in gaining the social competencies of personal efficacy in manipulating their natural environment, and making it do what they want it to do, and in dealing effectively with other people in a work situation. For these purposes, a third idea in the curriculum is that students work individually or in small groups, and are responsible for selecting, planning, and managing all of their own activities. The teacher's role is neither laissez-faire nor directive, but encouraging the students, participating with them in activities, clarifying their problems, assisting them in interpreting results, and so forth. The small group organization provides opportunities for children to develop skills in explaining things to other people and to learn from each other. To provide more contact with adults, many of the activities involve students in going out into the community to collect data.

Fourth, separate instructional materials are provided for each activity with only enough copies for a few student groups to make it more difficult for teachers to teach the course by lecture. These materials include a wide variety of worksheets, phamplets, equipment, and films. There are no textbooks. Because of the flexibility that this form of packaging provides, and the problem-oriented structure of the curriculum, it is easy for teachers and students to add units to the course and they are encouraged to do this.

Unified Science and Mathematics for the Elementary School

The Unified Science and Mathematics for the Elementary School (USMES) curriculum project was the outgrowth of the 1967 Cambridge Conference on the Correlation of Mathematics and Sciences in the Schools,* that recommended the development of curriculum in which the subject areas of mathematics and science would be integrated through work on problems that are practical and real to students. This general recommendation has been converted into a curriculum for the elementary schools by the USMES project. There are three main ideas in the USMES curriculum.

First, the USMES curriculum presents students with real problems, or "challenges" as they are called for the explicit purpose of facilitating the development of cognitive strategies as distinct from intellectual skills. For this purpose, the "challenges" are problems that are broad enough not to immediately suggest a clear-cut path to a solution. The problems are ones that the developers have found to be "real" to the students in the sense that they have encountered them and find it interesting to search for a solution rather than the "real" to what adults think children's problems are. The problems that have been selected mostly concern children's physical and social environment--how to redesign a street crossing to make it less dangerous, how to improve the school's playground, finding ways of learning faster, and so forth. The problems included in the course have been identified mainly through working with teachers in classrooms. There is no hierarchy or conceptual structure of problems.

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*[Goals for the Correlation of Elementary Science and Mathematics](#), The Report of the Cambridge Conference on the Correlation of Science and Mathematics in the Schools, Houghton Mifflin, Boston, MA, 1969.

Second, the developers maintain that the purpose of the program will not be achieved unless all the phases of the problem-solving process are performed by the children, including problem definition, generation of alternatives, evaluation of alternatives, and decisionmaking. Furthermore, research is cited that many different problem-solving strategies can be identified and that no single strategy can be shown to be best in all situations. Therefore, no student activities are specified and the teacher's role is to introduce a general problem and then support the children in their deliberations and chosen activities. For this purpose, teachers are provided with a series of background papers on the mathematical concepts and scientific phenomina that may arise during student work. There is also a large number of "How-To" cards explaining mathematical calculations, construction and use of measuring instruments, the recording and displaying of data, and so forth for teachers to give to students as needed. These cards provide much of the subject matter content of the course in helping the students with tasks involving mathematical computation, scientific measurement, and data presentation.

Third, implementation of the USMES course requires a separate room, called a "Design Lab" where tools, materials, and work space are available for students to construct and test apparatus needed in their investigations without disrupting ongoing activities. All the supplies can be purchased locally.

THEMATIC STRUCTURE OF THE SCIENCE CURRICULUM PROJECTS

In order to provide an overview of the educational significance of these five NSF science curriculum projects and the general directions in which they were attempting to change the school science curriculum, two common themes running through the ideas listed are summarized in this section.

Concrete Manipulation of the Environment

One theme running through the ideas in the science curriculum projects described is that students should have more opportunities in school to actively reconstruct knowledge for themselves through concrete manipulation of their natural environment and spend less time than in the past reading baout the conclusions of science and memorizing what others say that they should know. Manipulation of the concrete is uniformly seen by the developers as extremely important both for later learning of abstract concepts and acquiring thinking skills. Even the BSCS curriculum, which involves less opportunity for concrete manipulation than the other curricula that we described (which may be appropriate at the high school level), advises a shift in laboratory activities from demonstration of previously learned facts to experimental investigations prior to classroom study of a subject. As stated in Paigetian terms by Strauss, the hypothesis of the science curriculum developers is that "concrete operational virtuosity" must be acquired before transition to the level of formal reasoning can be achieved, and that opportunities to achieve such knowledge is severely lacking in the school curriculum.*

The developers attach greater importance to learning to higher order cognitive skills than subject matter facts generally for reasons of longer range educational benefit to students and society. The benefit to students is generally that they will gain skills useful in thinking analytically about everyday problems and be more capable of integrating future scientific and technical developments into their thinking. The benefit to society is that the students will have a deeper understanding of science and therefore make more informed decisions as citizens and leaders. In terms of the central problem of curriculum improvement discussed in the second section of Chapter II, each of these "benefits" is a particular way that the science curriculum developers have thought that continuities between schooling and the needs of individuals, communities and society can be strengthened.

With respect to the components of the school curriculum defined in Chapter II, these changes in the science curriculum of providing for more concrete experiences to emphasize the acquisition of higher order cognitive skills imply needs for shifts from symbolic to enactive materials, and to increase in student control of subject matter. Enactive materials are necessary to allow similation of natural phenomena in the school setting, while greater student control of subject matter is necessary to allow students sufficient freedom to manipulate these materials for themselves and to think at higher cognitive levels. Increasing student control of subject matter entails changes in teacher behavior.

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*Sidney Strauss, *Learning Theories of Gagne and Piaget: Implications for Curriculum Development,* Teachers College Record, Vol. 74, No. 1, September, 1972.

A diagram of this thematic structure and its implications for the school curriculum is shown in Fig. ___.

Presentation of Subject Matter in a Meaningful Context

A second theme running through the ideas in the curriculum projects described is that the subject matter in the school science curriculum should be changed so that it is presented to students in contexts that are more "meaningful" to them than in conventional programs.

Interpretations of what is "meaningful" to students vary widely among the projects described according to the curriculum philosophy adopted but generally involve presenting subject matter in ways that build on student's previous educational experiences outside of school and respond more directly to their personal interests. In BSCS, the scientists thought that presenting subject matter in the context of its relationship to the unifying concepts form the discipline (such as organic evolution and adaptation to the environment) would make the study of biology more meaningful to students through showing them the powers of knowledge to explain seemingly diverse phenomena with which they may already be familiar or that they might encounter in the future. The scientists assumed that these powers of knowledge to unify and predict, which are a source of deep meaning to them, having both aesthetic and utilitarian qualities, would have similar meaning for students. In the Human Sciences Program, the developers worked from an assumption that subject matter should be selected according to the cognitive and social, developmental needs of students. Once these needs were determined then subject matter that addressed these needs was selected from scientific knowledge. In ESS, the interpretation of meaningfulness is that the subject matter of science should be presented to children in a context that is within their realms of previous experience with their natural environment. Thus, the motions of the earth are studied through investigation

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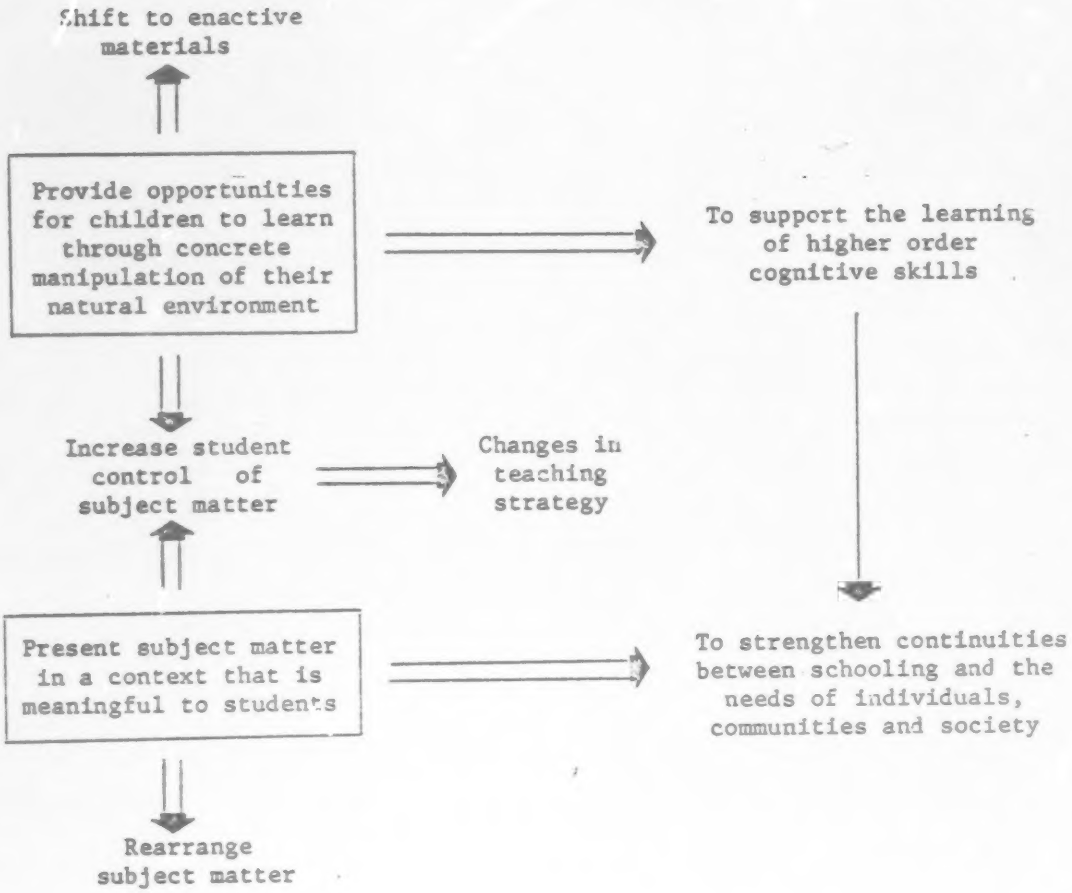
Shift to enactive materials
Provide opportunities for children to learn through concrete manipulation of their natural environment
To support the learning of higher order cognitive skills
Increase student control of subject matter
Changes in teaching strategy
Present subject matter in a context that is meaningful to students
To strengthen continuities between schooling and the needs of individuals, communities and society
Rearrange subject matter

Fig. —Thematic Structure of Science Curriculum Projects of shadows cast on the ground or on the blackboard and not from pictures of planets whirling around in the solar system. As these examples indicate, the ideas for making subject matter more meaningful to students are much deeper than the more traditional approach in curriculum of showing examples of how knowledge is used in solving practical problems (e.g, that biological knowledge can be used to breed disease resistant plants).

Similarly to the previous theme of providing increased opportunities for concrete manipulation of the natural environment, the ideas in the science curriculum projects for making subject matter more meaningful to students can be interpreted as ways of strengthening continuities between the interests and previous educational experiences of students and what they learn in school. These ideas are deeper than simple notions of making schooling more relevant through selective assignment of existing subject matter content to students according to their skill needs as id often the case in attempts to individualize instruction, in that the intent is to reformulate and convert scientific knowledge into forms that make its usefulness to students more readily apparent.

With respect to the components of the school curriculum defined in ChapterII, the ideas in the science curriculum projects for presenting subject matter to students in a more meaningful context typically may require rearrangement of subject matter. In BSCS, the rearrangement is organizing content around conceptual themes. In TMMW the rearrangement is an entirely new course, and so forth. In most of the projects described, the ideas for presenting subject matter is a more meaningful context also involve giving students more opportunity to choose subject matter according to their interests, which, in the language of this study, is equivalent to giving students more control of subject matter.

EVIDENCE OF EFFECTIVENESS

An immediate question is whether these changes in the school curriculum advanced by the NSF science projects have been found to produce any effects on students learning. Although deficient in many respects, the many evaluation studies of the new curricula reported in the education research literature are the most readily accessible source of data. The major problems with these studies are that the research designs do not often account for intervening variables and outcome measures are not always closely matched to treatments.

Subject Matter Presentation

Walker and Schafferzick[*] have reviewed this literature and extracted 23 studies that met the minimal criteria of having an experiment and a control group, and an "objective" test for measuring student outcomes. The control groups had studied a subject from a traditional textbook curriculum and the experimental group an "innovative" curriculum. None of these studies had random assignment of curricula to teachers, and only two had random assignment of students; but, in approximately one-half of these studies, some statistical procedure was used to compensate for initial differences in academic ability (typically a regression on pre-tested I.Q. scores). The authors did not report whether the studies had any controls on treatment implementation, but from our knowledge of the literature it is unlikely that any of the sutdies attempted to account for this variable.

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[*] Decker F. Walker and Jon Schafferzick, "Comparing Curricula," Review of Educational Research, Vol. 44, No. 1, Winter 1974, pp. 83-111.

There is a further problem in that the review included evaluations of more than just NSF science projects and did not distinguish studies by types of innovations. However, ten of the 23 studies were of early NSF high school science curricula and five were of the School Mathematics Study Group (SMSG) curriculum, commonly known as the "New Math." The SMSG curriculum is very similar to the NSF high school science curricula in that the innovations mainly involve changes in subject matter, including the introduction of new subject matter and the organization of content around concepts from mathematics. The other eight studies were mostly of innovative English and social studies curricula at the elementary and high school levels.* Thus, the studies reviewed are predominately of curricula containing innovations similiar to the early high school science projects.

In general, the results of the review are that the innovative curricula are effective in achieving their objectives, as shown in Tables 1 and 2. Table 1 summarizes the tested comparisons in all of the studies reviewed, and shows that the experimental groups scored higher than the control groups on almost every tested comparison where the test favored the innovative curriculum, while the control groups only tended to score higher on tested comparisons where the tests favored the traditional curricula.** Although the total

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*At least two of the three social studies curricula evaluated were inquiry oriented, similiarly to the early high school science projects.

*All the tested comparisons were significant at least at the .05 level of significance using either a "t" or an "F" test.

Table 1

SYNTHESIS OF ALL RESEARCH STUDIES REVIEWED
(number of tested outcomes)

	Innovative More Effective than Traditional	Innovative Less Effective than Traditional	Innovative Equally Effective to Traditional	Total
st used vored the novative rriculum	44	1	7	52
st used vored the aditional rriculum	5	9	16	30
t possible determine ich curricu- favored	4	3	9	16
ALS	53	13	32	98

SOURCE: Ibid., p. 92.

Table 2

SYNTHESIS OF ONLY RESEARCH STUDIES CONTAINING AT LEAST ONE TEST FAVORING EACH CURRICULUM
(number of tested outcomes)

	Innovative More Effective than Traditional	Innovative Less Effective than Traditional	Innovative Equally Effective to Traditional	Total
st used vored the ovative rriculum	28	1	2	31
st used vored the aditional rriculum	3	8	10	21
.S	31	9	12	52

SOURCE: Ibid., p. 93.

number of comparisons where the experimental group scored higher than the control group is much larger than the total number of comparisons where the control group scored higher, a conclusion that the innovative programs are more effective overall is not warranted since the tests favoring the innovative programs may have been more closely matched to the innovative curricula than the tests favoring the traditional curricula were to the traditional curricula. Under these conditions, the large number of comparisons where the test favored the innovative curriculum may be distorting the overall results. To partially account for this problem, the authors summarized only studies where at least two tests were used with at least one favoring the innovative curriculum and one favoring the traditionalcurriculum. There were nine studies that satisfied this criterion, but as shown in Table 2, the results are not much different than in Table 1. Whether these results in Tables 1 and 2 reflect primarily the differences in subject matter topics covered or the acquisition of higher order cognitive skills is impossible to determine from the information contained in tl ke: and Schaffarzick review. The tests favoring the innovati ricula tended to emphasize reasoning skills more than the tests fa the traditional programs, but also the subject matter content cov 1 the innovative programs.

The data in Tables 1 and 2 ppear to indicate that while the innovative curricula are effe 'n achieving their objectives, they are not more effective in ach the objectives of the traditional curricula than the trad: curricula. In other words, the new curricula only shifts learnii v objectives and are not more effective ways of learning what h 'tionally been tuaght.

As we argued in the previous section, the intent of the new curricula has been to make the subject matter studied more relevant to student's interests and to shift learning to a higher cognitive level.

Manipulation of the Concrete

Because the Walker and Schaffarzick review contains no studies of activity-oriented elementary science programs, it does not yield any evidence regarding the effects of providing opportunities for concrete manipulation on student outcomes. The only review of elementary science programs that we could find indicates that the effects are substantial but is not systematic enough to allow any broad conclusions. Without specifying the universe of studies reviewed, this article reports many favorable findings. Some of these findings are that NSF's elementary science programs have been found to have statistically significant effects on achievement of problem-solving skills and certain categories of Piagetian concrete operations, as well as on IQ scores, reading readiness skills, verbal fluency, and language complexity.* Furthermore the studies that have considered differences in achievement by socio-economic groups have tended to find that disadvantaged groups do as well as other groups in learning science skills, and to gain more in language and reading skill areas. These results suggest the need for a more thorough review of the existing studies of the elementary science programs.

IMPORTANCE OF MATERIALS DEVELOPMENT

Because the studies reviewed did not control for the degree to which innovations in the new curricula were actually implemented by teachers, the results favoring the NSF science curricula can be interpreted as more a test of the effects of changing curriculum materials than the specific curriculum innovations intended. Or, in other words, the results favoring the NSF curricula are a test of whether or not changing materials alone has any effect on student learning. For effects to occur, it is probable that materials have to be highly unconventional in either their format, the subject matter presented, or the character of learning outcomes expected (i.e., higher order cognitive skills). The data in the studies reviewed are not sufficient to allow any firm conclusions to be drawn on this matter, since teachers were not randomly assigned to the innovative curricula in the studies reviewed (and therefore may have been naturally inclined to the new programs) and since some teachers may have received inservice training locally or through NSF teacher institutes even though this was not reported. But, since the production of materials is a distinctive feature of development as a strategy of change, the issue is important and deserves more attention than it has in the past.* In contrast to the usual no-significant-difference results in most evaluations of innovative educational programs, here we apparently find strong and consistent differences. Some additional but by no means conclusive evidence on the issue of the role of materials in educational change is considered in this section.

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*Mary Budd Rowe, "Help is Denied to Those in Need," Science and Children, March 1975, pp. 23-25.

In considering the role of materials, we are not asserting that teachers are unimportant, that support for implementation is unnecessary, or that many other school-level organizational factors do not matter. It is simply that materials should not be ignored as a potentially important factor in the educational change process. The notion is that if designed to an unconventional philosophy and structured to provide teachers with room for growth, materials can facilitate important change at the classroom level.

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*Decker Walker and Jon Schafferzick, op.cit., p. 103.

Student Recall of Topics Studied

One kind of evidence on the role of materials that we found concerns the effects of changing subject matter in materials on what subject matter is actually covered in the classroom. One measure of this effect is to correlate changes in the subject matter contained in materials with what students later remember that they have studied. If teachers tend to deviate substantially from the materials that they use, or as is often hypothesized are more effective in teaching the certain topics that they are for some reason more familiar with or enthusiastic about, then the topic emphasis in materials should not be very highly correlated with what students later remember that they studied.

We found one study addressed to this question and the results are that student recall of topics is highly correlated with the distribution of topic emphasis in the textbook that they used, as shown in Table 3. This study was a survey of 2500 high school seniors who were asked whether or not they had studied certain topics in biology.* Some of these students had used *Modern Biology*, the standard text for the high school level, and the rest one of the three BSCS versions (Blue, Green, and Yellow).** These four textbooks place substantially different

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*William Kastrinos, "A Survey of Teaching Practices in Biology in Secondary Schools," TDR-69-6, Educational Testing Service, May 1969.

**Students who had taken more than one biology course were eliminated from the survey.

Table 3

PERCENT OF SELECTED TOPICS IN BIOLOGY TEXTBOOKS RECALLED BY HIGH SCHOOL SENIORS

Textbook Used	Number of Students	Emphasis in the Text			
		None	Minor	Some	Major
Modern Biology	2318	29%	40%	52%	72%
BSCS Blue	110	39%	47%	67%	79%
BSCS Yellow	134	34%	48%	62%	80%
BSCS Green	95	40%	50%	64%	74%

SOURCE: William Kastrinos, "A Survey of Biology in the Secondary Schools," TBR-69-6, Educational Testing Service, May 1969.

NOTES: "None" is if the topic was not found in the textbook; "Minor" is if the topic was found in only one or two places in the text and less than a short paragraph was devoted to the topic in each case; "Some" is if there were several references and several paragraphs devoted to the topic; and "Major" is if the topic was given major consideration.

Table 4

DISTRIBUTION OF EMPHASIS AMONG SELECTED TOPICS IN *MODERN BIOLOGY* AND BSCS VERSIONS

		Emphasis in *Modern Biology*			
		Major	Some	Minor	None
Emphasis in *BSCS Blue*	Major	13	9	1	7
	Some	1	6	1	2
	Minor	1	4	6	3
	None	11	11	14	13
Emphasis in *BSCS Yellow*	Major	13	9	5	4
	Some	4	8	5	2
	Minor	1	4	7	3
	None	7	8	5	9
Emphasis in *BSCS Green*	Major	10	4	1	4
	Some	6	5	2	3
	Minor	4	9	2	3
	None	6	13	16	15

SOURCE: William Kastrinos, "A Survey of Biology in the Secondary Schools," TBR-69-6, Educational Testing Service, May 1969.

emphasis on the topics selected for the study, as shown in Table 4.[*] As was shown in Fig. _____, students normally take biology in the tenth grade; thus, these results were obtained two years after the topics were formally studied. Whether changing text curriculum materials has a causal influence on the topics covered by a teacher cannot strictly be determined from these data. Since, it is possible that the teachers of the students in this study were already emphasizing the topics emphasized in the BSCS Versions and simply switched to the BSCS texts when they became available without changing their teaching. However, it seems unlikely that such teachers would have uniformly chosen the topics that are emphasized in the BSCS texts. The high correlation of student recall of topics studied and emphasis in the BSCS texts strongly suggests the opposite -- that the emphasis in the BSCS texts had an influence on what subject matter topics the teachers are covered in in their biology classes. In addition, some of the correlation may be explained as due to students reading on their own from their materials eventhough the teachers are not covering the topics in class.

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[*] Some sample topics were DNA, biological imprinting, and miosis.

Classroom Interaction Patterns and Teacher Behavior

Another possible influence of materials is on classroom interaction patterns and teacher behavior. The question is whether there are any properties of materials that influence teachers to interact with student in a different way, to give them more discretion in chosing subject matter, or to allow them to work in smaller groups. The idea in the Human Sciences Program of providing only enough copies of an instructional unit for a few students in order to make it more difficult for teachers to lecture to the whole class is one example, and the manipulative materials in the elementary science program, which are also more difficult to use in the lecture mode than textbooks, is another. Since materials have only a supporting and not a constraining influence on teachers, the issue is not whether dramatic change occurs, but whether there are any properties of materials that induce teachers into making more change in their classrooms than they ordinarily would have.

Precise determination of the causal influence of materials is extremely difficult because there are so many confounding factors. We attempted to compare the results of existing research studies on innovative textbook curricula like the BSCS Versions with curricula incorporating manipulative materials like the NSF elementary science programs, but found that the outcome measures used were so inconsistent and controls on the amount of inservice training received by teachers so lacking, that no conclusions could be reached.

We found one study in the area of individualization in reading that indicates how complex and subtle the interactions between materials and teacher behavior may be. This study concerned the relationship between the degree of individualization in reading, the extent to which students are grouped for instruction, and the variety of materials used. Materials variety was simply defined as the number of different sets of materials being used in a classroom. Regarding the influence of materials, the issue is whether the mere availability of a wider variety of materials tends over a period of time to result in a higher level of individualization.

As expected, one finding in this study is that variety in materials usage and the extent of student grouping is highly correlated. As shown in Table 5, teachers in the sample who had all their students using the same materials tend to have whole-class instruction, while teachers grouping students for instruction tend to use a variety of materials. Unfortunately, it cannot be concluded from these data whether materials variety is a causal factor in explaining the extent of student grouping.

That materials variety may be a causal factor in expalining higher order teacher behavior was indicated by the results of another analysis in this study. This analysis involved correlating the extent of grouping and materials variety with two selected measures of the extent of individualization. One of the measures was called the "breadth" of the teachers decisionmaking base, which was measured with a 20-item scale of indicators such as amount of discussion with students on progress and work, the use of plans, and the use of outsid professional channels, and so forth, and found that this variable was significantly

Table 5

RELATIONSHIP OF CLASSROOM GROUPING PATTERN AND MATERIALS VARIETY IN ELEMENTARY READING
(number of classrooms)

Most frequent grouping pattern employed	All students use the same materials	Two-to-three groups with different materials	Four or more groups with different materials	Each student has different materials
Whole class	11	0	0	0
Two-three groups	7	41	1	0
Four or more groups	2	13	58	0
Students work individually	5	9	14	47

SOURCE: Joann K. Intilli and James E. Flood, "The Effect of Selected Student Characteristics on Differentiation of Instruction in Reading: The Meaning and Correlates of Individualization," Stanfrod Center for Research and Development on Teaching, unpublished report, 1976. The data shown were obtained from a questionnaire returned by 208 California teachers.

correlated (r= .18, p= .01) with the variety of materials used but not the grouping strategy employed. Another measure of individualization was the extent to which teachers evaluated the effectiveness of their teaching approach and changed their approach over time. More grouping was negatively correlated with the variable (r= -.15, p= .01), while variety in materials used had almost no correlation (r= -.04, not significant at p= .10). These negative correlations can be interpreted as indicating either that teachers employing a high level of classroom grouping and variation in materials are more satisfied with their teaching or that the greater complexity of a high level of grouping and materials variety forces them to cutback somewhere on their task load and they tend to choose reducing deliberate evaluation of their teaching effectiveness. Whatever the case, greater variety in materials used apparently leads to less reduction in evaluation of performance than high differentiation in grouping. The overall conclusion is that materials variety is more strongly associated with a high degree of individualization in reading than grouping. Or, in other words, the organizational intervention of grouping tends to be less effective in supporting individualization than the technological intervention of increasing materials variety.

In a broader context, the issue regarding materials variety and individualization is how strongly related diversity in the range of materials available from publishers is to the extent of individualization in the schools. It is possible that as the variety of materials available increases, teachers will, over time, gradually achieve a higher level of individualization through piecemeal incorporation of changes than if few real alternatives are available. However, as will be discussed in the next chapter, publishers are highly sensitive to market conditions and, therefore, the diversity of materials available from them is not likely to be much different than the diversity of materials in use by teachers across the country. Thus, in a crude sense, the diversity of materials available from publishers is in equilibrium with degree of diversity in the school curriculum at any point in time, and the rate of increase in the extent of individualization is consequently slower. Data showing that the number of programs available from publishers in different subject matter areas is highly correlated over time with curriculum diversity in those areas would support this hypothesis of an equilibrium but none could be found.

Extending this argument further, a possible effect of the introduction of curriculum innovations into the school curriculum through national curriculum projects may be to displace this equilibrium through either giving publishers ideas for new alternatives or increasing diversity in the school curriculum to which publishers respond. Either way, the hypothesis is that in the long run, the degree of diversity in the school curriculum may be increased through this indirect process in comparison to what iw would have been if the national curriculum projects had not been conducted.

The perspective being sketched here is that through an indirect and exceedingly complex porcess, national curriculum projects may have the effect of increasing the developmental capacity of the curriculum policy system in the sense that the capability of all institutions to adapt curriculum to students needs and interests is increased. Up to this point, we have not shown this to be the case, but more evidence will be presented in the remaining chapters. The critical issue is whether the effects of national curriculum projects are limited to the extent to which the materials produced are used or there are larger, more long-run system effects.

Historical Perspective

Another broad perspective on the role of national materials development in the process of educational change can be gained from viewing the ideas for improving the school curriculum advanced by the NSF science curriculum projects in historical context. In not describing the ideas in the science curriculum projects in a broader historical context, we may have left the impression that these ideas are completely new to education--that they represent a sharp discontinuity with previous thinking and action to improve the school curriculum. On the contrary, there are many similiarities to ideas for curriculum change proposed by educational theorists, philosophers, and blue-ribbon commissions in years past. What clearly distinguishes the national curriculum projects is that ideas for change were translated into tangible resources for teachers to use in the schools. Evidence that these ideas are now reflected in the school currciulum eventhough in historically perspective they are not new would be an indication of the importance of national materials development to educational change. In this section, we present historical background on the major ideas advanced by the science curriculum projects and in the remaining chapters of this report present all the evidence that we could find on the extent to which these ideas are currently reflected in the school curriculum. All of our observations will be brought together in the concluding chapter.

High School Biology. Hurd has reviewed the history of high school biology education since 1890 and found that the recommendations of national curriculum committees for improving the school curriculum have been consistently similar to the ideas advanced in BSCS.* A sample of Hurd's findings are sufficient to demonstrate his conclusion: In the period 1890-1900 which included the prestigous Committee of Ten, two of the recommendation were that biology should be taught as a laboratory science and that teaching should emphasize the broader principles of the discipline. In the period 1900-1910, it was again recommended that the emphasis should be shifted from teaching biological facts to the principles, ideas, and interrelationships of the discipline and also, that more emphasis should be given to the "scientific method" and that biology should be organized to capitalize on student interests and expereince. In the decade 1930-1940, two recommendations were: that, because knowledge acquired through a process of memorization is of little value in problem-solving situations, science is best learned as an association of facts culminating in a concept expressed as a principal or generalization of science; and, that there should not be a distinction between class and laboratory, since both should contribute to the solution of problems. BSCS defined the concepts of biology, produced materials organizing subject matter around the concepts, elaborated the idea of enquity teaching as a much more scientifically realistic approach to understanding the "scientific method," and developed laboratory manuals and lists of needed laboratory equipment.

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*Paul DeHart Hurd, Biology Education in American Secondary Schools, American Institute of Biological Sciences, Washington, D.C., 1961.

Manipulation of the Concrete. On the importance of experience with the concrete to the acquisition of formal knowledge, Whitehead wrote in his classic work, The Aims of Education, first published in 1929, that learning should start with a phase of "romance," as he called it, where the child should be free to see and act for him- or herself.* Following this, there should be a phase of

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*Alfred North Whitehead, The Aims of Education and Other Essays, The Free Press, New York, 1967, p. 53.

"precision," as he called it, where students are given "a way of analyzing the facts, bit by bit." Regarding the importance of this initial, "romance" phase to the second phase, Whitehead had this to say:

> ... a block in the assimilation of ideas inevitably arises when a discipline of precision is imposed before a stage of romance has run its course in the growing mind. There is no comprehension apart from romance. Without the adventure of romance, at the best you get knowledge without initiative, and at the worst you get contempt of ideas -- without knowledge.[*]

Whitehead believed that for "mental growth" an interplay between these phases in continuing cycles is required.[**]

Earlier, Dewey had written that:

> ... the essentials of method ...(for producing good habits of thinking)...are first that the pupil have a genuine situation of experience--that there be continuous activity in which he is interested for its own sake...[***]

But he also cautioned that:

> One method is the scrappy one of picking up isolated materials just because they happen to be familiar objects within the pupil's experience, and of merely extending and deepening the pupil's range of familiarily and then passing on to something else. No amount of this will make an introduction to education, to say nothing of science. The other eroneous course is taken when the teacher's imagination is so linked that he cannot conceive of science existing except in books under the heads of physics, chemistry, etc.,

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[*] Ibid., p. 33.

[**] Ibid., p. 19.

[***] John Dewey, Democracy in Education, MacMillan Company, New York, 1916, p. 192.

> and who is restricted to move within these boundaries. What is desired...is that starting from ordinary unclassed material of experience (the pupil) shall acquire command of the points of view, the ideas, and methods...(of science).[*]

These statements are fully consistent with the rationales in the NSF science curriculum projects for providing students with opportunities for concrete manipulation of their national environment. What the science curriculum projects did was convert these statements into tangible materials for teachers to use.

Progressive Education. In fact, Cremin has argued that the science curriculum projects are similar enough in underlying philosophy to the works of Dewey and other early progressives that the two should be seen as "essentially continuous."[***] Without providing all the here details, Dewey and the early progressives were primarily concerned with the social functions of the school and needs for reform being brought on by urbanization and industrialization. Progressive education stood for humanizing subject matter and making it more accessible to students;[****] teaching children how to think and not only how to memorize; and emphasizing moral and social as well as intellectual development.

In the Eight-Year Study, one of the most comprehensive educational evaluations that has ever been undertaken, the college performance of high school graduates from 30 progressive high schools was compared to a matched group of students from traditional high schools[*****] (the matching included socio-economic, demographic and

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[*] John Dewey, "Method in Science Teaching," General Science Quarterly, Vol. I, No. 1, p. 3.

[**] Hurd, op. cit., p. 42.

[***] Lawrence A. Cremin, The Genius of American Education, Univ. of Pittsburgh Press, Pittsburgh, Pa., p. 54.

[****] Ibid., p. 57.

[*****] Ralph W. Tyler, An Adventure in American Education: Did They Succeed in College? Fund for Advancement of Education,

academic ability measures), and the findings were that students from the six most progressive schools performed substantially higher than their counterparts from traditional schools. Eventhough the students took the same academic subjects, they had grade point averages in college that were .12 points (out of 4.) higher and received more academic honors; exhibited more sustained interest in pursuing specialized intellectual interests; were more precise, systematic, and objective in their studies; participated more actively in contemporary affairs; tended to exhibit much broader humanitarian concerns; and were more educationally mature in the clarity of their ideas and ability to express them. Students from all thirty schools were on the average superior to their counterparts in all these categories although not by as much. Students from the six least progressive schools performed only as well as their counterparts from other schools. Yet, despite this demonstrated success of the experimental schools, progressive education failed to significantly affect American education. While all the reasons cannot be explored here, many authors have noted the failure of progressive educators to convert their often fuzzy philosophical statements and ideas for practice into programs and resources for the schools. In fact, progressive educators insisted that pre-made instructional materials were antetethical to the whole philosophy of progressive education. Student's sense of responsibility for their own education, teachers understanding of what they were teaching, the functioning of the classroom as a democratic social group, and the relationship of schools to needs and interests of students and communities would all be undercut by packaging progressive education into material forms.

However, expecting teachers to make or assemble all of their own materials makes a substantial claim on their time and especially when the educational philosophy to be implemented is vague and there are few persons around who have a command of that philosophy. Hawkins has stated that where progressive education succeeded

> ...it did so because the world of children's exploration was amply provisioned with subject matter they could explore well, could penetrate deeply. Where it failed, it did so because the freedom for active involvement was inadequately provisioned. This inadequacy was often concealed by a preoccupation, illegitimate in the absence of provisioning, with the maturation of the child personality....*

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*David Hawkins, "The Informal Vision: An Essay on Science Education," ESS Reader, Education Development Center, 1970, pp. 79-80.

Chapter IV

INFLUENCE OF THE NEW CURRICULA ON PROGRAMS PRODUCED BY COMMERCIAL PUBLISHERS

A. INTRODUCTION

Many proponents of large-scale federally funded curriculum development claim the Curriculum Reform Movement has had a widespread secondary effect of influencing the subject matter content, format, and instructional methods of curriculum programs financed and developed exclusively by educational publishers. The reason most frequently given for this secondary effect is that publicly financed curriculum development efforts have served as models of new and superior instructional approaches and that private publishers find it to their advantage to pick and choose ideas from the federally sponsored curriculum projects when creating their own programs. Determining the validity of these claims is important for assessing the impact of the Curriculum Reform Movement. Should it be the case that educational publishers have typically extracted ideas from the national projects when modifying existing curricula or creating new instructional programs, more students may be experiencing the innovations of the new curricula than the adoption figures for the federal programs reveal. This would suggest that the impact of the initial project is most appropriately understood as one distributed over a much larger student population than that reached by the materials produced directly with federal funds.

Of greater significance, however, is the potential that understanding the mechanisms behind such naturally occurring "multiplier effects" holds for designing more effective government programs for the support of curriculum development activities. If officials in government agencies understand what influences publishers to adopt and adapt features of federally sponsored curricula for use in their own curricula, they would be in a better position to fund curriculum development work that is likely to have desirable secondary impacts on commercially developed programs.

The work described in this chapter touches on these two areas. Namely, we sought to determine:

- What is the evidence for the claim that new curricula programs influence the programs of commercial publishers? And, if there is evidence of such secondary effects
- What are the forces that influence publishers to incorporate innovations from the national curriculum projects into their own programs?

Literature Review

We had originally planned to draw heavily on the reported literature for insight into these questions. However, a review of the literature revealed few studies that systematically assessed the secondary impact of the new curriculum programs on programs developed by commercial publishers. All of the work reported in this area did suggest, however, that the commercially developed programs show at least some influence of the programs that resulted from federally financed curriculum development projects.

For instance, the developers of the federally supported CHEM STUDY program examined ten high school chemistry books published since 1963 to determine if they demonstrated consistency with the CHEM STUDY philosophy, objectives, and content (Gladieux, R.J., 1967). They concluded that five of the ten books reflected the general philosophy and content of CHEM STUDY. Three of the books that did not appear to be strongly influenced by CHEM STUDY demonstrated some minimal influence as measured by the inclusion of up-to-date material on phases of matter; the mole concept; energy, rate and equilibrium characteristics of chemical reactions; orbitals and the like.

A report prepared by the Conference Board of the Mathematical Sciences National Advisory Committee on Mathematical Education (1975) appraises the extent of implementation of the recommendations of the new math projects and reports that the federally sponsored curriculum groups have influenced the topics included in commercial texts available at the elementary, junior high school and high school levels. At the elementary level, many curricula incorporate varying amounts of geometry, probability and statistics, functions, graphs, equations, inequalities and algebraic properties of number systems. Widely used commercial junior high texts cover the language and concepts of sets, algebraic properties of number systems, non-standard numeration systems, informal properties of number systems, and number theory. Similarly, commercial high school texts reflect the incorporation of themes stressed in the NSF sponsored School Mathematics Study Group (SMSG) project including treating inequalities along with equations, presenting proofs in algebra and integrating plane and solid geometry with co-ordinate methods.

Capron et al. (1973) interviewed the editorial staff of six publishing firms to determine if federally funded curriculum projects in the social sciences had had any impact on social studies textbooks. All of the publishers interviewed agreed that the federal projects had influenced their programs and several publishers cited specific instances where a curriculum project had provided ideas for a commercial program. Based on their inspection of currently available social studies texts, these investigators conclude that the curriculum movement has influenced several aspects of the commercial programs through, for instance, encouraging the use of organization structures that emphasize conceptual learning rather than fact memorization and through motivating the integration of materials from social science disciplines into the various texts.

Although these studies clearly suggested the existence of secondary effects, the presence of such a trend must be put forth with some caution inasmuch as the reports of the studies contain little information on how the researchers defined key terms or on the methods of data collection, analysis, and interpretation. Moreover, none of the studies reported on the timing of secondary influences, thus making it impossible to know if the trends evidenced were in effect prior to the curriculum reform period. Nor did any include any information that would cast light on the forces behind the secondary effects observed.

Because we believed that understanding the dynamics of secondary effects of federally sponsored projects is exceedingly important to formulating effective programs for the support of curriculum development, we decided to carry out some research that would assess the incorporation over time of innovations from NSF curriculum projects into curricula developed by commercial publishers.

The Basic Approach

Our basic approach was to select certain dimensions of the school curriculum described in the conceptual framework (chapter II) and to determine if these dimensions of commercially developed programs had undergone change over time consistent with the innovations or ideas put forth in one or more NSF curriculum projects.

Because our resources were limited and analyses of this sort are exceedingly time consuming, we were only able to trace the pattern of incorporation of three innovations of the National Curriculum Projects. However, as Table I indicates, the innovations selected are common to several national curriculum projects and therefore are intended to be examples that illustrate more general phenomena.

In the case of two of the innovations, *updating subject matter content* and *organizing material around conceptual schemes*, it was necessary to examine textbooks page by page to assess incorporation. We therefore used several editions of a single commercial program, Holt, Rinehart and Winston's *Modern Biology* to trace the incorporation of the innovation. This commercially developed traditional high school biology textbook had dominated the high school biology market for at least a decade prior to the introduction of the federally supported BSCS programs, thus making it a good candidate for a longitudinal study. It should be noted, however, that we could have chosen an earth science, chemistry, physics textbook to trace the incorporation of either of these innovations because both were common to the early National Curriculum Projects in each of these subjects. Among these subjects, however, biology seemed the most appropriate choice because more students enroll in biology than in any other high school science (Osterndorf, 1975). For the third innovation, non-textbook formatting (*i.e., designing curricula around kits and other manipulative materials)*, incorporation could be assessed more easily and we therefore extended our analyses to a large number of commercial programs.

Each of the next three sections describes one of the three longitudinal studies we conducted on the incorporation of an innovation of the curriculum reform movement into programs of commercial publishers. A general discussion of the nature of the innovation proceeds the description

Table I

THE SCIENCE CURRICULUM INNOVATIONS STUDIED

Curricular Dimension	General Innovation of the NSF Programs	NSF Programs Having the Innovation	Example of the Effect in the Classroom	Commercial Programs Examined
Subject Matter Time Allocations: Content Strands	Update and redistribute subject matter content to more accurately reflect the current state of the scientific discipline.	BSCS (Biology) CBA (Chemistry) CHEM STUDY (Chemistry) ESCP (Earth Science) PSSC (Physics)	Biology students spend more time studying molecular bioyogy, cellular biology, ecology and human behavior. Textbooks include less taxonomy and general physiology.	Holt, Rinehart and Winston, *Modern Biology*, 1956, 1960, 1963, 1965, 1969, 1970 editions.
Skills Emphasis: Intellectual Skills	Organize materials around a few conceptual schemes that are central to understanding the scientific discipline.	BSCS (Biology) CBA (Chemistry) CHEM STUDY (Chemistry) ESCP (Earth Science) PSSC (Physics)	Biology texts give increased emphasis on a few general patterns and concepts applicable to all levels of biological organization (e.g., structure is related to functions); there is decreased emphasis on memorizing minor details at all levels.	Holt, Rinehart and Winston, *Modern Biology*, 1956, 1960, 1963, 1965, 1969, 1970 editions.
Materials Presentation: Non-textbook Formatting	Make kits or other manipulatives central to the curriculum.	ESS HSP SAPA SCIS USMES	Students spend classroom time participating in experiments and other activities designed both to develop an understanding of scientific principles and to convey scientific knowledge. Quiet desk work is minimized.	Elementary Programs listed in El-Hi Textbooks in Print 1955-1975

of the methods used to assess incorporation into commercial programs and the findings with respect to the extent in incorporation of the innovation over time. A discussion of factors that have influenced the extent of secondary impact of the new curricula programs follows the presentation of the three incorporation studies.

B. UPDATING AND REDISTRIBUTING THE SUBJECT MATTER CONTENT EMPHASES OF SCIENCE COURSES

The Innovation

A primary goal of the curriculum developers of the early science projects was to produce textbooks that would reflect the current state of knowledge in the respective science disciplines. In general, the developers maintained that the "traditional" textbooks developed by educational publishers were badly outdated, reflecting a scientific outlook that went back half a century, and were therefore no longer representative of the views of the scientific community. If included at all, current developments were tacked onto these traditional texts, giving them a patchwork quality that totally overlooked the unity of a scientific field. Moreover, the new curricula developers maintained that traditional texts had given increasing attention to the application of science and to other technological considerations while minimizing the attention given to scientific concepts important to the fields (Marshall and Burkman, 1966; Hurd, 1969). As Hurd notes:

> "In the traditional courses the assumption is frequently made that the easiest way to learn science is through technological applications. The scientists developing the new programs do not believe the true nature of science can be taught in this way. In support of their position they point to the number of students having had high school science who are unable to distinguish science from technology." (Hurd, p. 45)

In light of these considerations, the BSCS, CPA, CHEM Study, ESCP, and PSSC projects all had as a central objective updating the subject matter content of the curricula in their respective areas. Implicit in this goal was the notion that the new textbooks not only had to include new discoveries, but also had to redistribute the emphasis given the various topics covered in the curriculum to more appropriately represent the current state of the field.

In the BSCS project, the developers had a general philosophical position that explained their notion of updating subject matter content and that guided the selection and organization of content for the three BSCS versions they produced:[1]

> The major aim of BSCS biology is to present a valid image of current biological science. A field of knowledge can be viewed in terms of major dimensions that aid in describing what constitutes the field. Three of these dimensions are the subjects to be investigated, the major generalizations and conceptual schemes which result from and give focus to investigation, and the modes of investigation. For biology, the subjects of investigation can be organized in terms of *levels of biological organization.* Major generalizations have been identified in the form of *themes*, which permeate the BSCS materials, and modes of investigation are presented in terms of details of biological *enquiry*. (Biological Sciences Curriculum Study, 1970, p. 9).

Levels of Biological Organization was the dimension we selected to study to determine whether traditional commercially developed programs had incorporated the BSCS programs approach to content emphasis into their textbooks. The BSCS developers identified seven levels of biological organization that reflect natural boundaries of inquiry within the discipline of biology. These are:

Level	Sample Topic
1. The Molecular Level	Biochemical Reactions in Plants
2. The Cellular Level	Cell Division
3. Organ and Tissue	The Digestive System of A Mammal
4. The Organism as an Individual	Territorial Behavior of Geese
5. The Population	Factors Influencing Population Size of Various Animal Species
6. The Community	The Food Web in a Pond
7. The World Biome	Worldwide Distribution of Flora and Fauna

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[1] The three BSCS versions are: Biological Science: An Ecological Approach (BSCS Green Version; Rand McNally and Co., publisher); Biological Science: An Inquiry into Life (BSCS Yellow Version; Harcourt, Brace and World, Inc., publisher); and Biological Science: Molecules to Man (BSCS Blue Version; Houghton Mifflin Company, publisher).

The BSCS developers maintained that traditional courses in biology presented an image of the field as it existed in past centuries when the major task of the biologist was to observe organisms, direct them, and describe their anatomical and physiological features. This had resulted in a situation where traditional courses overemphasized the organ and tissue level and failed to present adequate information on the remaining six levels of organization that constitute the areas of most active inquiry and advances during the current century. In other words, the developers maintained that traditional courses in biology had tended to overemphasize the organ and tissue level and had failed to devote adequate attention to either the more micro- levels (#1 and #2) or to the higher levels of organization (#4, #5, #6, and #7).

In accordance with these criticisms, they called for a reorientation of emphasis outward in both directions from the rough centering on organs and tissues:

> "In recent years the development of biology has taken it outward in both directions from this rough centering on organs and tissues. In the downward direction it has penetrated first to the cellular level and more recently to the molecular level.
>
> Explorations at these levels have led to correction, enlargement, and reorganization of our knowledge of organs and tissues, because study of cellular architecture and molecular behavior has thrown a new light on the actions and functions of organs.
>
> This reorganized knowledge of organs and tissues has, in turn, helped open to us certain higher levels of biological organization. We have returned to the ancient center of interest —the whole organism—and we are gaining new knowledge of the behavior of that whole: how it learns; how it develops patterns of behavior without learning; how it carries on such fundamental processes as courting, mating, and nesting; migration, self-defense; and aggression.
>
> We are also moving beyond the organism as an individual to a study of populations, treating the population as a subject in its own right and not merely as numbers of individuals. We are studying the growth and decline of populations, their sickness and health. Through population genetics we are even, in a sense, studying the mating and reproduction of populations.
>
> Beyond the population of similar organisms, we are invading the organized community of diverse organisms, too. We are discovering some of its component parts, its diverse "organs" and

> how these "organs"--various kinds and types of organisms--act to fulfill the roles, occupy the niches, that constitute the community of which they are parts.
>
> We have even begun to study the world biome as a whole, the totality of "life stuff," all kinds and varieties of organisms taken together and studied for their universal characteristics--how life, as such, originates and evolves; the directions in which evolution takes it; the necessary conditions for existence of life; and the repertory of ways in which living units can respond to varying conditions.
>
> There is no better way, therefore, to introduce the character of the BSCS biology texts than by showing how they differ from other texts in their treatment of the various levels of biological organization." (Biological Sciences Curriculum Study, 1964, pp. 9-10).

This is a clear example of a national curriculum project advocating an alteration in the attention given various topics within a particular subject area which would result in a reallocation of the time devoted to various content strands within the curriculum.

General Methods

In order to determine if the traditional program incorporates the innovation, we developed a content analysis methodology to enable us to assess the extent to which revisions in the editions of commercially developed programs that had been available prior to the curriculum reform movement reflected the reorientation in subject matter emphases stressed in the national BSCS project.

The questions we wished to answer using this methodology were:

- How and when had the content strand emphases of the traditional textbook program changed?
- To what extend have the changes been consistent with the changes in emphases advocated by the BSCS program?

We applied the methodology to assessing changes in content emphasis of several additions of Holt's *Modern Biology* which, as was noted previously, dominated the high school biology market for several decades prior to the introduction of the BSCS textbooks.

Subsections were the basic unit of analysis. The subsection is a portion of text within a chapter that generally speaks to a single topic which is highlighted in boldface type at the beginning of the subsection. In *Modern Biology* textbooks the subsections are typically 3-5 paragraphs long, although some are only a paragraph in length and others cover as much as two pages of written text. Subsections can typically stand as isolated entities in that their meaning is not altered when they are taken out of the context of the chapter. Similarly, a subsection can be removed from a chapter without distorting the meaning of the remaining text.

We generated the data for the analysis in two stages. During the first stage, called the *revisions analysis*, we identified those *Modern Biology* subsections that had been either deleted or added during successive revisions of the textbook. We used the data from this analysis to determine:

- when the publishers had made changes;
- the magnitude of those changes; and
- the overall extent to which the text had changed over time.

During the second stage of the analysis we examined the revised portion of the textbook (i.e., the subsections identified as additions or deletions) to determine if the overall changes in subsections were consistent with the topical emphases advocated by the BSCS developers. Thus it was during the second stage of the analysis that we have termed the levels of emphasis analyses that we collected the data most pertinent to the incorporation issue.

The Revisions Analysis

Methods. During the revisions analysis we paired and compared six versions of the *Modern Biology* text published by the Holt Company (i.e., the 1956, 1960, 1963, 1965, 1969, and 1973 versions) to identify subsections that either: (1) remained substantially intact from a given earlier edition to the later edition; (2) had been added to the newer edition; or (3) had been deleted from the older version. We used the following criteria for identifying the various types of changes in *Modern Biology:*

- *Identifying substantially intact subsections*: A subsection is considered substantially intact if either a, b, or c is applicable:

  a) The subsection heading in the new edition is the same as or explicitly comparable to a subsection heading appearing in the prior edition.[1] Examples of explicitly comparable headings are:

    -How sponges reproduce vs. Sponges reproduce in several ways
    -The nature of carbohydrates vs. What are carbohydrates?

  b) Over half the key terms and concepts emphasized by boldface or italic type in the subsection in the new edition are the same as those appearing in the text of the earlier edition. (Note that two or more subsections from an earlier version are sometimes combined to form one subsection in a later version; combinations of subsections into a single subsection are considered substantially intact if this criteria holds.)

  c) The main point in over half the paragraphs of the subsection in the new edition are the same as those made in the text of the earlier edition. (The consideration of combined subsections also holds for this case.)

- *Identifying additions* (i.e., subsections that have been added to the newer edition). All subsections *not* coded as substantially intact in the newer edition are considered new subsections or "additions."

- *Identifying deletions* (i.e., subsections of the older edition that do not appear in the newer edition), A subsection is considered to be a deletion if a or b are applicable:

  a) Over half the key terms in boldface or italic type do not appear in a later version of the text

  b) The main points made in over half the paragraphs of the subsection are not apparent in the later version.

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[1] Careful comparison of editions revealed that in cases of explicitly comparable headings there was typically little change in the actual text of the subsection.

Using these criteria, we compared the 1956 version with the 1960 version to identify those subsections that had been in the 1956 version that no longer appeared in the 1960 version (i.e., "deletions"); we also noted those subsections that appeared for the first time in the 1960 version (i.e., "additions"). Likewise, we compared the 1960 version with the 1963 version and noted which subsections that appeared in 1960 had been deleted in 1963 and which subsections appeared for the first time in 1963. Proceeding in this way, we identified five sets of deletions and additions: 1956-1960; 1960-1963; 1963-1965; 1965-1969; 1969-1970. Each set of deleted and added subsections represent the textual changes in one edition of the *Modern Biology* book. In other words, the 1956 deletions - 1960 additions are the changes that took place in the 1960 edition of *Modern Biology*; the 1960 deletions - 1963 additions are the changes that took place in the 1963 version, and so on.

Magnitude of the Changes

Table II displays the numbers of subsections added and deleted in each of the *Modern Biology* version lengths. There were a total of 560 subsections changed during the period covered by the study. Three hundred (54%) of the changes resulted from the addition of new subsections of text in a given edition while 260 (46%) of the changes resulted from the deletion of material that had appeared in the prior edition. The fact that there were more additions than deletions and that the additions were on average approximately two inches longer than the deletions contributed to a 25 percent growth in the amount of written text in the 1973 edition as compared with the 1956 edition.

Table III gives two indicators of the magnitude of the changes made in the various revisions of *Modern Biology*. By dividing the total of inches of written text in a given year by the total number of inches of written text in new subsections, it is possible to compute the percent of written material in a given edition of the textbook that did not appear in a previous edition. Similarly, by dividing the number of inches of the subsections that appear in the previous edition but that was eliminated in a new edition into the total number of inches of the previous edition, it is possible to determine how much of the previous edition was considered inappropriate for the updated version.

Table II

SUBSECTIONS ADDED TO AND DELETED FROM *MODERN BIOLOGY* OVER TIME

		Year						
		1956	1960	1963	1965	1969	1973	Total
Additions Subsections included in the given year that did not appear in the previous edition	Number of subsections	--	83	6	132	46	33	300
	Total length* of subsections	--	475.6	50.6	1104.3	375	247.3	2252.8
	Average length* of subsections added (in.)	--	5.73	8.43	8.36	8.15	7.49	
Deletions Number of subsections appearing in given year that were deleted when the next edition was published	Number of subsections	12	10	169	16	53	--	260
	Total length* of subsections	70.5	64.0	876.25	104.3	226.9	--	1341.95
	Average length* of subsections deleted	5.88	6.40	5.18	6.52	4.28	--	
Textbook length*		**	5264.8	5669.9	5698.5	5630.2	6561.0	

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*All measures of length are reported in column inches. Because the column width changed when the editions were revised, the figures have been adjusted to afford comparability and represent a 2-1/2 inch column width.

**Not available.

Table III

MAGNITUDE OF SUBSECTION CHANGES IN *MODERN BIOLOGY* OVER TIME

Year of Edition	Percent of Text That Was New to the Edition	Percent of Text That Did Not Appear in the Subsequent Edition
1956	—	1.3*
1960	8.4	1.1
1963	0.9	15.4
1965	19.6	1.9
1969	6.0	3.6
1973	3.8	—

*Estimated figure

Pattern of Change

The data in Tables II and III reflect two striking irregularities. First is the relatively large proportion of change reflected in the 1965 edition of *Modern Biology*. This edition of *Modern Biology* accounts for 303 subsection changes, about 54 percent of the total change observed over the 17 year period spanned in our analysis. As Table III indicates, close to 20 percent of the written text appearing in 1965 was new to the *Modern Biology* series and the revision processes for the 1965 edition had resulted in the elimination of about 15 percent of the written text from the previous (1963) edition. Thus, these changes from 1963-1965 were far in excess of the amount of change required to establish a new edition copyright.[1] This is in contrast to all the other revisions reported where the percent of new written text was more closely in line with copyright requirements. Noteworthy, however, is the exceedingly small amount of new text in the 1963 version. Only one percent of the written material appearing in 1963 was new to the *Modern Biology* series and the subsection changes observed for that edition accounted for only three percent of total changes evidences in our study.

The second striking irregularity also centers on the 1963 and 1965 versions of *Modern Biology* in that the timing of the publication dates of these versions deviates from the usual timing between new editions. Publishers normally put out a revised edition of a successful textbook once every four years. And, as Table I indicates, four years was the span between the 1956 and 1960 editions, the 1965 and 1969 editions, and the 1969 and 1973 editions. However, in the first five years of the 1960s, Holt published two new *Modern Biology* editions. The publication of the first of these revised editions coincided with the release of the first editions of the BSCS biology programs. The second of these "untimely" editions, the one that reflects substantial change as discussed above, followed the publication of BSCS by only two years.

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[1] The copyright laws are vague with respect to how much change is necessary for a new copyright to be issued. The copyright application provides two lines for the applicant to describe what is new in an updated version of a previously published book. New matter may consist of compilation, translation, abridgment, editorial revision, and the like, as well as additional text or pictorial matter. Thus it is possible for an updated version to only differ from the previous edition by virtue of editorial changes or changes in some of the pictures. It is common knowledge that the publisher of a highly successful series is most likely to make only minor changes when revising that series as there is generally little to be gained by modifying a product that has enjoyed continued market success. If the majority of teachers are satisfied with a series, a publisher may risk reducing the market for a textbook when the new edition is substantially different from the previous editions.

Levels of Emphasis Analysis

Methods. The second stage of the content strand study was designed to determine the extent to which the changes identified in the revisions analyses were consistent with the BSCS developers' contention that the content of biology courses should be redistributed so as to deemphasize subject matter on organs and tissues and on applied technology in favor of an emphasis on other biological levels that would represent "outward movement" from the organ-tissue core. Our approach was to code each addition and deletion with respect to a category of content emphasis that represented either the BSCS or traditional approach and to note whether the overall changes indicated the incorporation of the innovation.

Pilot work indicated that all of the deleted and added subsections could be classified as falling into at least one of seven content categories. Changes coded in four of these categories had direct significance for determining the extent of incorporation of the BSCS innovation (Table IV).

The addition of subsections coded in two of the categories, Molecular-Cellular and Behavior-Population-Biome, was viewed as being consistent with the BSCS advocated content redistribution in that they represented the "movement outward in both directions from the Organ-Tissue level" mentioned above. Deletion of material in these categories was judged inconsistent with the BSCS advocated content redistribution.

Conversely, material added in two other categories, the Organ-Tissue Morphology category and the Applied category was viewed as inconsistent with the BSCS advocated content redistribution, while the deletion of material in these categories was judged consistent with the BSCS approach.

The three remaining emphasis categories we included were "Science Discipline," "History-Scientific Processes," and "Non-Substantive."

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[1] The coding manual appears as Appendix A.

Table IV

SUMMARY OF CODING CATEGORIES FOR THE LEVELS OF EMPHASIS ANALYSIS

	Relationship of Category to BSCS Position	Significance of Coding in the Category
Molecular-Cellular	Material coded here represents movement outward to more "micro" levels advocated by BSCS. Two BSCS levels subsumed in category are molecular level; cellular level	Additions consistent with incorporation of BSCS innovation Deletions inconsistent with incorporation of BSCS innovation
Organ-Tissue-Morphology	BSCS critical of traditional texts for over-emphasis of this category	Deletions consistent with incorporation of BSCS innovation Additions inconsistent with incorporation of BSCS innovation
Behavior-Population-Biome	Material coded here represents movement outward to more "macro" levels advocated by BSCS. Four BSCS levels subsumed in this category are: o organism as an individual o the population o the community o world biome	Additions consistent with incorporation of BSCS innovation Deletions inconsistent with incorporation of BSCS innovation
Applied	BSCS critical of traditional texts for over-emphasis of this category	Deletions consistent with incorporation of BSCS innovation Additions inconsistent with incorporation of BSCS innovation
Science Discipline	These categories neutral with respect to the innovation	No significance
History-Scientific Processes		
Non-substantive		

We considered these categories to be neutral with respect to the BSCS advocated content redistribution. That is, we did not consider the material coded in these emphasis categories to be reflective of either a BSCS or a traditional thrust. Science-Discipline was applicable when background material from a discipline other than Biology was emphasized. History-Scientific Processes was coded when a subsection described methods of scientific inquiry or specific historical events but offered no substantive information from the field of biology. Thus, a subsection was considered to reflect this emphasis only when no other emphasis category was coded in conjunction with it. This generally occurred only in those cases where the subsection was one paragraph long. When History-Scientific Processes was coded in combination with other emphasis categories, we considered it to reflect a theme (see the themes analysis below). We reserved the non-substantive category for those cases where the subsection conveyed content essentially irrelevant to biology or other sciences.

Extent of Content Redistribution

Analysis of the data generated in this portion of our study (Table 5) indicates that *Modern Biology* has undergone a change in content emphasis that reflects the reforms advocated by the BSCS group. It is evident from the pattern of emphasis of the added and deleted subsections, that the changes for any single year are distributed among several different content categories and that no particular category dominates the changes over time. However even though the size of the changes in various emphasis categories may seem relatively small in any given year, the cummulative changes for all categories over several editions was substantial enough to result in a noteworthy redistribution of content among the categories of interest. As Figure 1 indicates, a cumulative total of 335 subsection changes consistent with the BSCS approach to content redistribution were evidenced in editions published between 1960 and 1973, while there were only 198 subsection changes inconsistent with the BSCS approach during the same period. The greatest change consistent with BSCS-type content distribution took place in the 1965 edition when a net total of 139 BSCS-consistent changes were evidenced in *Modern Biology*. Since BSCS was first published in 1963, there have been 312

Table V

PATTERNS OF EMPHASIS IN DELETED AND ADDED *MODERN BIOLOGY* SUBSECTIONS

		Edition					Cumulative Total
Category		1960	1963	1965	1969	1973	
Organ-Tissue Morphology	**Add**	30	0	32	20	8	
	Delete	3	3	32	3	12	
	Difference	+27	-3	0	+17	-4	+37
Applied Field	**Add**	28	0	12	3	15	
	Delete	2	6	89	5	31	
	Difference	+26	-6	-77	-2	-16	-75
Molecular Cellular	**Add**	5	6	36	8	5	
	Delete	0	1	4	1	1	
	Difference	+5	+5	+32	+7	+4	+53
Behavior-Population-Biome	**Add**	13	0	55	12	9	
	Delete	3	1	25	3	11	
	Difference	+10	-1	+30	+9	-2	+46
cience Discipline	**Add**	15	0	6	5	5	
	Delete	1	2	13	5	3	
	Difference	+14	-2	-7	0	+2	7
History-Scientist Processes	**Add**	2	0	5	3	0	
	Delete	1	0	21	1	1	
	Difference	+1	0	-16	+2	-1	-14
Non-Substantive	**Add**	0	0	0	1	0	
	Delete	2	0	3	0	0	
	Difference	-2	0	-3	+1	0	-4

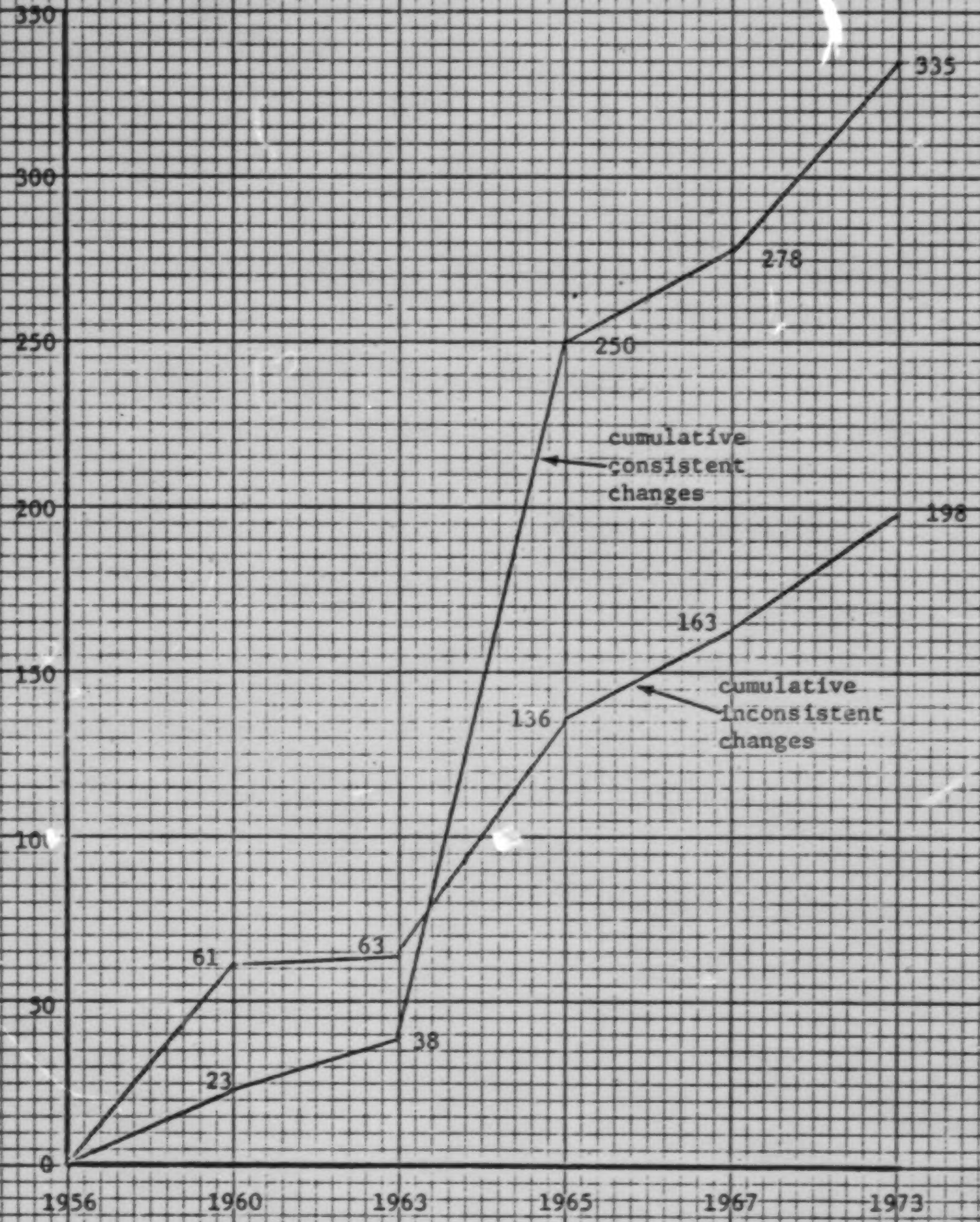

Fig. 1--Cumulative Subsection Changes in *Modern Biology* Consistent and Inconsistent with the BSCS Approach

changes consistent with BSCS and 137 changes that were not consistent, resulting in a net total of 175 changes consistent with the BSCS innovation. This contrasts with changes evidenced in the 1960 version of *Modern Biology* which resulted in a net *decrease* of 38 subsections consistent with the BSCS approach to content redistribution.

The data presented in Table VI converts the subsection changes into column inches of text in order to better illustrate the magnitude of the changes discussed above. They show that a net total of 987.1 column inches of written text or approximately 17 percent of the written text has been redistributed in a manner consistent with the incorporation of the BSCS innovation since the first publication of the three BSCS versions.

Changes Prior to BSCS. Figure 2 summarizes the net changes over time in each of the four emphasis categories we identified as being indicative of the extent of innovation incorporation which resulted in the overall trends noted above. For each edition we computed the net change in a category by subtracting the number of subsections in the category that appeared in the previous edition but were no longer evidenced in the new addition (i.e., deletions) from the number of subsections in the category that appeared in the given edition for the first time (i.e., additions). The figure uses 1956 as the baseline, enabling us to see that the overall changes made in *Modern Biology* prior to the publication of the BSCS texts tended to be inconsistent with the BSCS approach with respect to content redistribution. From 1956 until 1963 the predominant net effect of the *Modern Biology* revisions was to add subsections in categories that the BSCS developers said should be deemphasized. During this period there were small net gains in the two categories the BSCS developers said should receive more emphasis. However, in one of these, the behavior-population-biome category, the net additions actually drop in the *Modern Biology* edition published in the same year BSCS became commercially available. In other words, in three of the four categories, the publishers' changed behavior prior to BSCS' commercial availability was inconsistent with the BSCS approach.

Table VI

COLUMN INCHES OF ADDED AND DELETED SUBSECTIONS*

Category		Edition					Total	Cum.
		1960	1963	1965	1969	1973	63-73	Total
Organ-Tissue Morphology	Add	171.0	5.7	267.5	163.0	59.9		
	Delete	17.4	6.4	163.2	19.5	51.6		
	Difference	153.6	- .7	104.3	143.5	8.3	255.4	40.9
Applied Field	Add	159.6	0	100.3	24.5	112.4		
	Delete	11.6	19.2	453.9	32.5	133.3		
	Difference	148.0	-19.2	-353.6	- 8.0	-20.9	-401.7	-253.7
Molecular Cellular	Add	28.5	50.4	301.0	65.2	37.5		
	Delete	0	6.4	20.4	6.5	4.3		
	Difference	28.5	44.0	280.6	58.7	33.2	416.5	44.5
Behavior-Population-Biome	Add	74.1	0	459.8	97.8	67.4		
	Delete	17.4	6.4	127.5	19.5	47.3		
	Difference	56.7	- 6.4	332.3	78.3	20.1	424.3	48.1

*Calculations based on average subsection lengths as presented in Table II.

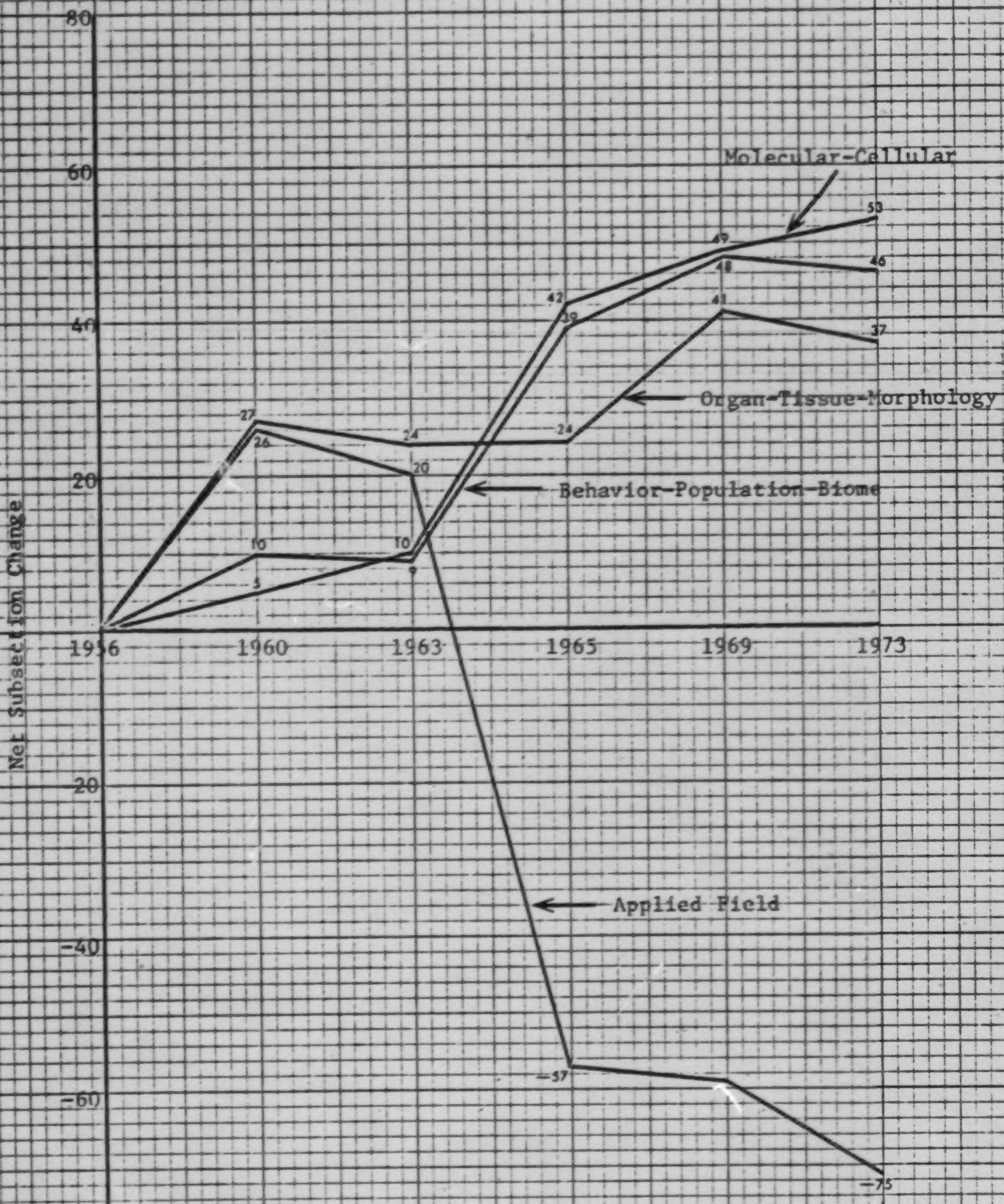

Fig. 7--Summary of Net Changes in FOUR Emphasis Categories Since 1956

MADE IN U.S.A.
10 X 10 PER INCH

Changes After BSCS. It is not until the publication of the 1965 edition of *Modern Biology*, however, that we see movement strongly compatible with the BSCS approach to content redistribution. In that year, none of the net changes in emphasis categories were inconsistent with the BSCS approach and movement in three of the four categories of interest demonstrated substantial change that was in line with the BSCS philosophy. Revisions compatible with the BSCS emphasis have predominated in the more recent edition of *Modern Biology*; in only two of the 12 changes portrayed in Fig. 2 (i.e., the net addition of 17 sections coded at organ-tissue-morphology in 1969 and the net deletion of two behavior-population-biome subsections in 1973) were the changes introduced by the Holt publishers inconsistent with the BSCS innovation.

Nature of the Changes

In the molecular-cellular and the behavior-population-biome categories, the two categories corresponding to areas BSCS writers maintained should receive more attention in the high school biology curriculum, the net changes in *Modern Biology* over the past six editions has been a net increase of a roughly comparable 53 and 46 subsections respectively. Although both of these net changes are consistent with the incorporation of the levels of emphasis innovation, the patterns of change within the two categories varied somewhat. This is suggested by the fact that in the molecular-cellular category there was only a total of 67 changes across all editions studied, all but seven of which were additions of new subsections to the text. This contrasts with the higher level of activity evidenced in the behavior-population-biome category where the total of 132 subsections changed included 89 additions and 43 deletions.

The activity in the molecular-cellular category is best characterized as one of strengthening an area by adding new material and by discussing topics previously covered in the text in considerably greater depth. For instance, the pathbreaking work of Watson and Crick on the structure of DNA is first treated in a single subsection only in the 1963 edition of the *Modern Biology* text. This contrasts with a substantially expanded coverage of topics related to DNA in the 1965 edition where a large portion of a chapter is devoted to the structure and replication of DNA. In addition, several other chapters discuss such topics as the role of DNA in protein synthesis and the relationship of DNA to gene structure and function.

Similarly, the coverage of topics related to genetics has increased markedly since 1965. In 1960 the principles of heredity and discussions of both plant and animal breeding and genetics applied to human inheritance were among the last topics discussed in the textbook.[1] Close to twice as much attention is now devoted to these topics and they are currently covered in the second unit of the eight unit textbook. Other changes in the molecular-cellular category were the expansion of the treatment of the biochemical processes of photosynthesis and plant respiration and the addition of several subsections on transport mechanisms between cells. The seven deletions of molecular-cellular subsections were scattered across years and topical areas.

In the Behavior-Population-Biome area, the character of the text was altered substantially by both the deletion and addition of subsections. The most striking change was the deletion in the 1965 and 1969 versions of close to all the material that had previously been included on "Forests and Conservation." Typical of the level of material on these topics was the following subsection on the Rocky Mountain forest that appeared in the 1963 *Modern Biology* but was *deleted* from the 1965 edition:

> *Rocky Mountain forest.* About half of the western forest belt occupies the slopes of the Rocky Mountain ranges and is called the *Rocky Mountain forest.* Deserts, sagebrush lands, and plains occupy the valleys between mountains while the mountains themselves support forests because of decreased temperature and increased rainfall due to elevation. The forests occupy definite zones, extending up the slopes to the tree line. Among the most prominent trees of the western forest are ponderosa pine, lodgepole pine, Engelmann spruce, Colorado spruce, Douglas fir, Idaho white pine, true firs,

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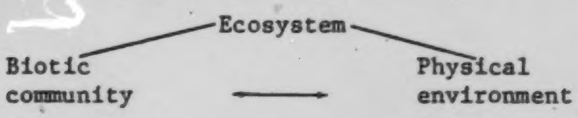
[1] Since the text often includes more material than teachers can complete in a year, the final chapters are frequently left out of a course; thus it is possible that large numbers of biology students were never exposed to this material.

> and aspen. Millions of tourists admire the beauty of the Rocky Mountain forest each year as they travel to national parks and other scenic areas.

The blandly descriptive tone of this and other deleted subsections tends to contrast with the more explanatory tone of the majority of the subsection additions. The following excerpt of a subsection that appeared for the first time in the 1965 edition is typical of such additions.

> In discussing the various parts of the ecosystem, we have not mentioned the nonliving component. This is called the *physical environment*. As you will see, it has an important influence on living things. The ecosystem, therefore, can be more completely represented in the following way:
>
> 
>
>
> Three kinds of relationships occur in an ecosystem: 1. the interactions in the biotic community; 2. the interaction between the biotic community and the physical environment; and 3. the interactions among the physical factors of the environment (p. 662).

In the behavior-population-biome category the addition of material on entirely new topics most distinguished the more recent versions of *Modern Biology* from the versions released prior to the publication of BSCS. Among these changes are the addition of several chapters and subsections of chapters that discuss organic variation and change mechanisms in living populations and material on the patterns of plant and animal behavior.

The greatest change in a *Modern Biology* content category took place in the "applied" area where the *Modern Biology* publishers changed a cumulative total of 187 subsections. A cumulative total of 133 subsections were deleted while only 58 were added,[1] thus creating a situation where the 1973 edition had 79 fewer subsections in the applied area than did the 1956 version. This overall removal of applied material strongly supports the BSCS contention that the content of biology texts be redistributed to deemphasize applied aspects of biology.

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[1] Over half of the applied category additions were made prior to the publication of BSCS.

Although the overall high rate of deletions in this category clearly supports a BSCS orientation, it should be pointed out that one would have expected to find relatively more activity in this category than in other emphasis categories inasmuch as publishers regularly manipulate applied topics when updating their programs. Publishers have traditionally relied on the addition of current day popular applications of biological knowledge as the basis for stressing the up-to-datedness of their new version. That this was the case in *Modern Biology* prior to 1960 is suggested by examining the substance of the 28 subsections added to the text in 1960: Thirty-six percent of these subsections were relevant to space biology, a popular topic of the period. Several other applied subsections discussed radiation and biology, focusing on concerns such as the sterilization of foods by radiation and medical uses of radiation. The majority of these subsections were deleted in the 1965 version. The preparation of the 1965 edition also involved the deletion of other applied subsections on such topics as medical technology, food technology, the economic importance of various animal groups that had been embedded throughout the 1956, 1960, and 1963 versions.

However, what is most striking about the activity in 1965 was that there were essentially no additions of "current applications" of biology. It is not until the publication of the 1973 version of *Modern Biology* that any significant amount of applied material was reintroduced into *Modern Biology*. And even these 15 subsection additions, which primarily focus on drug abuse and conservation, are offset by the deletion of 30 other Applied subsections, most of which discuss topics, such as crop rotation, that are related to agriculture.

The organ-tissue-morphology was the one category coded in which the overall actions of the *Modern Biology* publishers were inconsistent with BSCS recommendations. Although BSCS developers advocated a relative reduction in the coverage of material at this level, revisions of the text resulted in a net increase of ten subsections. Both additions and deletions in this category have tended to be scattered throughout the text and generally do not reflect noteworthy changes in topical emphases. An exception, however, has been the addition in 1965 of several subsections which comprise a chapter on human reproduction and development. These topics had not received attention in any earlier versions of the textbook.

The fact that the *Modern Biology* publishers did not act in accordance with BSCS recommendations that the organ-tissue-morphology area be deemphasized while acting in accordance with other content emphasis recommendations suggests to us that they believe material at this level should continue to occupy a considerable portion of the biology curriculum. This is not entirely unexpected as publishers are typically cautious about doing away with core portions of a textbook that has had a successful history. Thus while the publishers of this commercial program have added materials in those categories the BSCS developers believed should be emphasized, they have been reticent to remove much material at the biological level that has always been central to their program. It should be noted, however, that although the *Modern Biology* publishers continue to add material at the organ-tissue-morphology level, the added subsections tend to be at a conceptual level consistent with other BSCS recommendations for improving biology. Data collected in the course of the themes analyses which reflects another BSCS innovation, the structuring of content around conceptual schemes, revealed that 65 percent of the changes that have been made at the organ-tissue-morphology level since BSCS became commercially available favor theme incorporation and thus a higher cognitive treatment of material in this category. Prior to the publication of BSCS, 60 percent of the changes in the organ-tissue-morphology category were inconsistent with theme incorporation.

Summary

Taken together, the revisions and levels of emphasis analyses provide evidence that the BSCS innovation of updating and redistributing the subject matter content of science courses was incorporated into the commercially developed *Modern Biology* program. The revisions analyses shows that of the six *Modern Biology* editions released since 1965, five reflect an amount of change in the written text that is consistent with what would be expected on the basis of copyright requirements. However, the edition that followed the commercial release of the BSCS textbooks reflected substantially greater changes than would be expected on the basis of copyright requirements alone. Moreover, this edition was published two years earlier than would have been expected on the basis of previous and subsequent behavior of the publishers.

The levels of emphasis analyses showed that close to 70 percent of the subsection changes in *Modern Biology*, starting with the changes from the 1963-1965 edition, are alterations that reflect a move toward content redistribution advocated by the BSCS developers. Prior to 1965, over 60 percent of the changes had been inconsistent with the BSCS approach.

C. SKILLS EMPHASIS: THE INCORPORATION OF CONCEPTUAL SCHEMES

The Innovation

Determining criteria to use for selecting and organizing content for a new curriculum program is one of the major challenges of curriculum development work. In general, the curriculum developer is confronted with a situation where there is far more information available than could ever be included in a single course and the task of the developer is therefore one of eliminating large amounts of material that could potentially be incorporated in a given subject and deciding how to effectively structure the remaining content to meet the instructional goals.

One of the ways the early NSF science project developers approached the problem of selecting and organizing subject matter content was to build the courses around conceptual schemes derived from the theoretical structure of the discipline being studied. The rationale for using such schemes stemmed from the developers' belief that structuring courses in this way would enhance a student's ability to think conceptually. It was believed that developing the ability to think conceptually was important for developing problem skills. Advocates of the conceptual scheme approach also maintained that placing knowledge in the context of unifying principles of the discipline would increase the intellectual capacity of the learner to continually integrate new and changing knowledge. More specifically, developing conceptual skills was thought to contribute to such abilities as generating new ideas, defining problems, organizing and making interpretations of data, formulating principles and providing explanations for observed phenomena (Hurd, 1969).[1]

In the early NSF science curriculum projects, conceptual schemes were operationalized as themes that were woven throughout the various textbooks. As the examples in Table VII indicate, the developers formulated the themes at varying levels of specificity. Moreover, the themes fall within the *substantive* or *process* dimensions of the disciplines. In chemistry and physics (i.e., the physical sciences) are expressions of fundamental theories. This is in contrast to earth science and biology (i.e., the descriptive services) where the substantive themes generally represented the parameters of a set of interrelated concepts. Process themes generalized across sciences in as much as they encompass the basic methodological underpinnings of all scientific endeavors (Hurd, 1969).

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[1] There is no precise agreement on the definition of a conceptual scheme. In a broad sense, conceptual schemes can be thought of as a network of concepts related in a systematic way. Such schemes reflect the overriding uniformities or regularities that guide the interpretation of observations in systematic inquiry. Hurd (1967) presents an exceptionally clear and insightful discussion of the role of conceptual schemes in science curriculum development. Other writings that elucidate this area include Broudy et al. (1971) and Schwab (1971).

Modern Biology Incorporation of BSCS Conceptual Schemes

Methods. In order to determine if there is any evidence of commercial publishers adopting the conceptual schemes approach to skills development of the curriculum reform movement high school science projects, we examined successive revisions of *Modern Biology* for evidence of changes consistent with the incorporation of BSCS themes. As was the case in the levels of organization analyses, we used subsections as the unit of analysis for the study and examined each added or deleted subsection for the presence of themes as defined below. With respect to themes, the publishers could take three actions that would be considered consistent with conceptual scheme incorporation:

- adding a subsection with a theme;
- deleting a subsection not having a theme; or
- adding a theme to a remaining subsection (i.e., rewrite a subsection to include a theme).

Similarly there were three actions that would be inconsistent with conceptual scheme incorporation:

- adding a subsection not containing a theme;
- deleting a subsection with a theme; or
- deleting a theme from a remaining subsection (i.e., rewrite a section to eliminate a theme).

Table VII

FIGURE SAMPLE THEMES FROM NSF SCIENCE CURRICULUM PROGRAMS

CHEMICAL EDUCATION MATERIAL STUDY (CHEM STUDY)

Substance Themes

--energy and its role in chemical reactions
--conservation of mass-energy in terms of the conservation of atoms and electrical charge
--kinetics and mechanics of chemical reactions
--dynamic equilibria
--competitive factors acting in chemical systems in general
--electron structure and the geometrical arrangement of atoms

Process Themes (stated in terms of student abilities)

--to accumulate information through experimental observations
--to organize information and to observe regularities: to evaluate and interpret data
--to use a model system to account for observed behavior
--to communicate his findings from observations to others
--to appreciate the meaning of uncertainty in science or the absence of certainty
--to recognize that a theory or law need not be correct in every context to be useful in a limited context

BIOLOGICAL SCIENCE CURRICULUM STUDY (BSCS)

Substance Themes

--change of living things through time: evolution
--diversity of type and unity of pattern in living things
--the genetic continuity of life
--the complementarity of organism and environment
--the biological roots of behavior
--the complementarity of structure and function
--regulation and homeostasis: preservation of life in the face of change

Process Themes

--science as enquiry
--the history of biological conceptions

Our resources limited us to only those subsections that had been identified as additions or deletions in the revisions analysis (pp. Subsections that had been coded "substantially intact" were therefore not entered into the analysis. A cursory comparison of the "unchanged" text of the 1960 and 1973 versions of *Modern Biology* suggests that it is likely that this limitation led us to underestimate the extent of theme incorporation as some of the substantially intact subsections appear to have been rewritten to include themes.

Similarly, resources limited us to only examining *Modern Biology* subsections for evidence of five of the nine BSCS themes. This was another factor that would likely result in a conservative estimate of theme incorporation. Of the five themes we did examine, three involved substantive aspects of biology. These were:

- the change of living things through time: evolution;
- the complementarity of organism and environment; and
- the complementarity of structure and function.

Two of the themes focused on process dimensions. These were:

- science as enquiry; and
- the history of biological conceptions.

We designated a separate coding category for each of the first three themes and grouped the remaining two themes in a single coding category called "History-Scientific Processes." This was because the presentation of content in the context of science as enquiry often overlaps the presentation of the history of biological conceptions. A summary of the criteria for coding themes appears in Table VIII. Note that it was possible for a single subsection to incorporate more than one theme.

Extent of Theme Incorporation

From Table IX and Fig. 3 it is apparent that subsection changes *inconsistent* with the BSCS approach to theme incorporation dominated in *Modern Biology* revisions until the publication of the 1965 *Modern Biology*

Table VIII

SAMPLE CRITERIA FOR CODING THEMES

Examine each subsection to determine if one or more of the four themes described below are reflected in the subsection. Themes should be coded only when explicitly apparent; that is, when it is possible to underline the words that indicate the presence of the theme. Not every subsection will evidence a theme.

Theme 1: Complementarity of Structure and Function

- Check this theme category if the subsection relates biological structure to biological function in such a way as to illustrate why a particular structure is suited to a particular function.
- Check this theme category if the subsection demonstrates that biological structure can be used to infer biological function.

Theme 2: History-Scientific Processes

- Check this theme category if the subsection discusses the general methods through which scientific knowledge is generated.
- Check this theme category if the subsection presents the details of a study or group of studies undertaken to explore questions of scientific interest.
- Check this theme category if the subsection discusses how people's thoughts about or knowledge of aspects of biology have changed at different points in history.
- Check this theme category if the subsection discusses the nature of science, the kinds of questions different scientists attempt to answer.

Theme 3: Complementarity of Organism and Environment

- Check this theme if the subsection explains how the function or dynamics of a biological entity (e.g., cell, organ, individual, population) are influenced by its environment.
- Check this theme if the subsection explains how a biological entity (e.g., cell, organ, individual, population) modifies the environment in which it exists.

Theme 4: Change of Living Things Through Time

- Check this theme category if the subsection describes the history of organisms--the sequence of events in past time from which the biological present has had its origins.
- Check this theme category if the subsection describes the processes through which organisms evolve over time (e.g., natural selection, adaption, mutation).

Table IX

PRESENCE OF THEMES IN ADDED AND DELETED SUBSECTIONS OF SUCCESSIVE *MODERN BIOLOGY* EDITIONS

	Subsections Deleted			Subsections Added		
Edition	With Theme*	Without Theme**	Total	With Theme**	Without Theme*	Total
1973	18 (34%)	35 (66%)	53 (100%)	11 (33%)	22 (67%)	33 (100%)
1969	5 (31%)	11 (69%)	16 (100%)	31 (67%)	15 (33%)	46 (100%)
1965	32 (19%)	137 (81%)	169 (100%)	80 (61%)	52 (39%)	132 (100%)
1963	1 (10%)	9 (90%)	10 (100%)	1 (17%)	5 (83%)	6 (100%)
1960	3 (25%)	9 (75%)	12 (100%)	19 (23%)	64 (77%)	83 (100%)

*Category inconsistent with theme incorporation.

**Category consistent with theme incorporation.

revision that corresponded with the commercial release of BSCS. After that changes began to consistently reflect the BSCS approach. Sixty-eight percent of the changes made beginning with the 1963 edition are consistent with the thematic approach of BSCS. This compared with only 29 percent of the changes being consistent with the themes aspect of the BSCS philosophy in the 1960 edition.

With respect to individual editions, the movement toward theme incorporation is strongest in the 1965 edition where 72 percent of the changes were consistent with theme incorporation. This drops off slightly in the 1969 edition where 68 percent of the changes are consistent with the BSCS approach to themes; however, in the 1973 version the movement toward theme incorporation drops off even more with only 53 percent of the changes being consistent with BSCS.

The activity of the *Modern Biology* publishers that was most influential in establishing this trend toward developing a text reflecting the themes of the discipline has been the removal of subsections not having themes. Since 1965 a total of 183 subsections without themes has been deleted from the *Modern Biology* program. During this same period a total of 122 subsections having themes was added to *Modern Biology*.

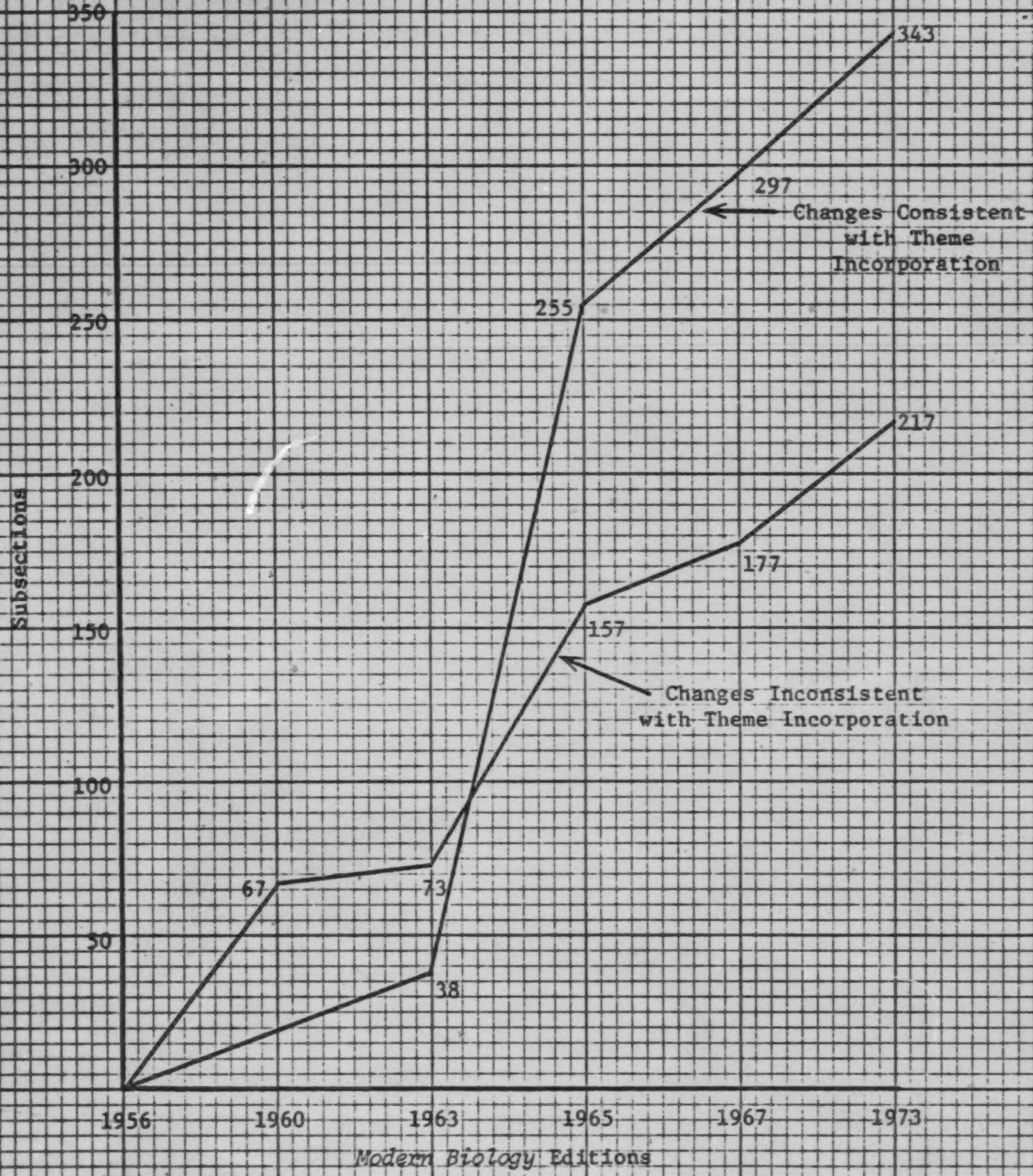

Fig. 3--Summary of Net Changes with Respect to Themes Since 1956

Nature of Theme Incorporation

When we examine the extent of incorporation of themes by theme categories (Table X) we find marked activity favoring theme incorporation in three of the four theme categories. Since 1956, the subsection changes have resulted in the incorporation of a net addition of 48 subsections reflecting the complementarity of organism and environment. Similarly, there has been a net addition of 39 subsections reflecting the change of living things through time as well as a net addition of 35 subsections dealing with the history and/or scientific processes of biology. The exception is the structure-function theme category. Here the net change does favor incorporation of the innovation, but the movement is quite weak as there has been very little activity when compared with the other theme areas. A total of only 16 subsection changes involving the structure-function theme was made in the editions studied, resulting in the net addition of two subsections reflecting theme incorporation over the five *Modern Biology* revisions.[1]

Theme incorporation activity was evidenced in portions of the text covering all levels of biological organization. This is illustrated by the theme distribution pattern in newly added subsections of the 1965 edition of *Modern Biology*. As Table XI indicates, each of the themes was introduced into several subsections at the Molecular-Cellular, Organ-Tissue-Morphology, and Behavior-Population-Biome levels. This pattern of incorporation of themes throughout the textbook suggests that the themes

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[1] A possible explanation for the lack of activity in the structure-function area stems from the fact that the core of high school biology has always discussed structures and functions of biological organisms. However, the concepts of structure and function have typically been treated as isolated entities with the relationship between the two given little attention. If subsections that describe biological structure or function did not undergo significant substantive revision, they would not have been identified as changes in the revisions analysis and therefore would not have been examined for the theme "complementarity of structure and function" in the themes analysis. Thus it could well be that our analysis underestimates the extent to which the publishers have revised *Modern Biology* to strengthen the idea that structure and function are closely interrelated concepts. Similarly, our findings with respect to modification of the conceptual level for all theme categories is likely to be conservative in that we only examined subsections that were added and deleted and there may well be incorporation of thematic material in the remaining portion of the text.

Table X

CATEGORIES OF THEMES INCORPORATED IN ADDED AND DELETED SUBSECTIONS OVER TIME

		Edition					
Category		1960	1963	1965	1969	1973	Total
History-Scientific Processes	Additions	3	0	32	6	3	44
	Deletions	2	0	4	3	0	9
	Net Change	+1	0	+28	+3	+3	+35
Structure Function	Additions	1	0	4	1	3	9
	Deletions	0	0	6	0	1	7
	Net Change	+1	0	-2	+1	+2	+2
Evolution	Additions	5	0	32	7	3	47
	Deletions	0	0	7	1	0	8
	Net Change	+5	0	+25	+6	+3	+39
Organism-Environment	Additions	11	1	42	22	8	84
	Deletions	2	1	17	1	15	36
	Net Change	+9	0	+25	+21	-7	+48

Table XI

DISTRIBUTION OF 1965 THEME ADDITIONS AMONG BIOLOGICAL LEVELS OF ORGANIZATION

Theme Category	Level of Biological Organization Molecular-Cellular	Organ-Tissue-Morphology	Behavior Population Biome
History-Scientific Processes	13	10	13
Structure-Function	1	1	3
Evolution	4	8	22
Organism-Environment	11	8	24
Total Subsections Added in 1965	36	32	55

do the function as unifying threads in the text that demonstrate similar concepts applied in the context of disparate content areas.

Varying Patterns of Theme Incorporation. However, although the themes are used as unifying threads, each theme was incorporated into the text in a somewhat different manner, thus emphasizing the variety of forms that may emerge when a seemingly straightforward educational idea is translated into practice. Excerpts from subsections additions with themes from the 1965 *Modern Biology* version offer a flavor for the way the *Modern Biology* publishers incorporated the theme of the "complementarity of organism and environment" for the various levels of biological organization (Table XII). Efforts to put forth the notion that biological entities influence and are influenced by the environment in which they dwell are embedded within subsections appearing throughout the text. Stated somewhat differently, it appears that the publishers chose to introduce the theme whenever it was appropriate to the context of the material being covered and the pattern of introduction therefore appears to be unsystematic.

This contrasts somewhat with the apparently more deliberate pattern of incorporation of the theme "change of living things through time" into the text. This theme appears quite frequently in an introductory subsection added at the beginning of a chapter and in a summary subsection

Table XII

THE INCORPORATION OF THE THEME "COMPLEMENTARITY OF ORGANISM AND ENVIRONMENT" INTO *MODERN BIOLOGY*

The excerpts below are examples of how the theme "complementarity and environment" was incorporated into newly added subsections in the 1965 edition of *Modern Biology*.

At the Molecular/Cellular Level:

> External factors that influence diffusion rates. In addition to molecular concentration, two other factors influence the rate at which diffusion occurs. One of these is *temperature*. The higher the temperature the greater the speed of molecular movement. This diffusion occurs from an area of higher temperature to one of lower temperature. Similarly, *pressure* accelerates molecular movement, resulting in diffusion from a region of higher pressure to one of lower pressure. . . . (p. 78).

At the Organ/Tissue/Morphology Level:

> Dynamic balance in the endocrine glands.
> . . . . Besides the influence of glands on one another, there are two other factors operating to produce the delicate check-and-balance system in body chemistry.
>
> In the first of these factors, called *feedback*, the accumulation of a substance in the blood automatically cuts down its production by the endocrine gland. For example, remember that parathormone regulates the level of calcium in the body. The concentration of calcium in turn regulates the production of parathormone. When the calcium level in the body drops, the secretion of parathormone increases to restore the calcium level. When the proper level is reached, the calcium influences the parathyroids to decrease their secretion. This same kind of feedback occurs in the other glands and between various glands. In this way a balanced state is automatically maintained in the normally functioning body. (p. 646)

At the Behavior/Population/Biome Level:

> What is the value of periodicity? As you are now well aware, an organism must be able to meet environmental changes in order to survive. You have seen many ways in which various organisms adjust to changes in the environment. The establishment of a synchronized rhythm for any entire population is of value for the survival of the species. The behavior of swarming grunion insures the aggregation of males and females

Table XII (Continued)

so the eggs can be fertilized. Male and female gametes of the oyster are shed into the surrounding water at the same time. Even though a female oyster may produce 114,000,000 eggs, her efforts would be futile if a neighboring male did not release sperm at the same time. (p. 693) near the end of the chapter. For example, the following excerpt from a subsection added to *Modern Biology* in 1969 to introduce the chapter on seed plants is typical of many others that have been added to introduce material on the various phyla of the plant and animal kingdom.

> The rise of seed plants
>
> The first forests appeared on the earth during the Devonian period of the Paleozoic era (Figure 22-1). Growing among the club mosses, horsetails, and ferns that composed these forests were the first seed plants, known as *seed ferns*. These ancient plants, now long extinct, were evolutionary products of the fern and ancestors of the modern seed plants that dominate the vegetation of the land today. Seed ferns were prominent in the swamp forests of the Carboniferous age. During the Permian period of the late Paleozoic era, they are believed to have given rise to other forms of seed plants, including cycads and conifers.
>
> With the dawn of the Mesozoic era some 200 million years ago, the climate of the earth became warmer and drier. These climatic changes led to the gradual disappearance of the seed ferns during the Triassic period. However, other seed plants continued to increase in number. The Jurassic period of the Mesozoic era marked the appearance of flowering plants, the most highly evolved seed plants. These plants developed rapidly during the Cretaceous period and have maintained their position of dominance to the present day. (p. 310)

In addition, the theme is now incorporated in many consecutive subsections in three chapters of the text. These chapters, all included in the second unit of the text, present concepts pertinent to evolutionary theory that were not included in the pre-1965 version of *Modern Biology*.

New curricula as model programs. In the case of the theme History-Scientific processes, the way in which the theme was incorporated in the *Modern Biology* text is particularly instructive in terms of the extent to which the *Modern Biology* text has moved closer to the BSCS ideal. The BSCS developers were explicit in describing the need for biology texts to detail the processes that have resulted in the generation of currently accepted biological knowledge:

> "The essence, then, of a teaching of science as enquiry would be to show some of the conclusions of science in the framework of the way they arise and are tested. This would

> mean to tell the students about the problems posed and the experiments performed, to indicate the data thus found and to follow the interpretation by which these data were converted into scientific knowledge." (Biological Sciences Curriculum Study, 1970, p. 23).

Having noted a substantial increase in the incorporation of this theme, we proceed to use the ideas outlined in the excerpt above as a guide for assessing how closely *Modern Biology* had followed the BSCS approach. We thus compared the 1960 and 1973 editions of *Modern Biology* to see if (1) biological findings were presented in the historical context from which they emerged, and (2) there had been attention given to the inquiry and investigative phases of biological science. We found a marked difference between the two versions. In 1960 there were 40 scientists mentioned in the text as compared with 69 scientists in 1973. For the most part, the 1960 version only presented the conclusions of an investigator's work. In only eight cases did the text provide any description of the actual experiment the researchers had undertaken. In contrast, the 1973 text details experiments carried out by 22 of the biologists. Moreover, the newer version frequently explains how the work of one investigator built on the foundation of another investigator's efforts.

For example, the 1960 version devotes one paragraph to the work of geneticist Thomas Hunt Morgan:

> *Causes of mutations.* The principles of mutation, in which genes may be lost or where combinations of genes may appear, were discovered by a famous biologist of recent years, Thomas Hunt Morgan. Much of his work was done with the fruit fly (*Drosophila*), a tiny insect which has been used extensively in research in genetics since his time. (p. 633)

In the 1973 edition, the discussion of Morgan's work is substantially expanded. The following is only an excerpt from that discussion...

> Now, let us return to the one fruit fly that made genetic history. One day Dr. Morgan and his associates were examining a large number of *Drosophila* and, to their surprise, found one fly that had white eyes instead of the normal red eyes. The fly was a male. This unusual fly was mated with a normal red-eyed female. All of the F_1 generation resulting from this mating had normal red eyes. By

> applying Mendel's principle of dominance, Morgan and his associates concluded that red eyes are dominant over white eyes in *Drosophila*. The investigation was continued with the mating of flies of the F_1 generation to produce an F_2 generation. About three-fourths of these flies had red eyes, and about one-fourth had white eyes. This, again, conformed with the results Mendel has obtained in garden peas that were hybrid, or heterozygous, for one trait. At this point, Morgan made a significant discovery. All of the white eyed flies were males! This could not have been the result of chance. There was a definite association of eye color and sex. Morgan had discovered a *sex-linked trait in Drosophila*. Two problems had now arisen: (1) sex determination in *Drosophila* and (2) the relationship of the gene for white eyes to sex. We shall now consider both of these problems.
>
> ### Sex Determination
>
> At the time when Dr. Morgan and his associates were experimenting with *Drosophila*, no one had examined its chromosomes. This was the next step for Morgan and his associates in the investigation of the white-eyed male. Examination of the nuclei of somatic cells of *Drosophila* revealed four pairs of chromosomes. . . (pp. 152-153).

The contrast between the two treatments is striking. The latter passage is best described as a "narrative on enquiry," a phrase coined by BSCS associate Joseph Schwab to denote a style of presentation in which the conclusions of scientific inquiry are presented as formulations of the evidence made available through a series of scientific investigations. The BSCS texts routinely cite the "narratives of enquiry" style as the context for presenting and explaining biological facts on principles, theories, and ideas. Clearly the *Modern Biology* publishers have always felt it important for students to have some knowledge of the history of breakthroughs in the field of biology as evidenced by the fact that names of famous scientists and the dates of key discoveries routinely appear in the various editions. However, it appears that the *Modern Biology* publishers adopted what they saw as an improved approach to presenting the history of biology from the BSCS versions. The data from our content analysis supports this view. In the years after BSCS had become available, 41 subsections added to *Modern Biology* incorporated History-Scientific Processes as a theme while only seven of the deleted subsections contained the History-Scientific-Processes theme. Moreover, in 1965, the year in which *Modern Biology* underwent the most drastic overall change, 21 subsections that presented facts about this history of biology or scientific processes without including material pertinent to any other emphasis category (i.e., with no substance other than historical facts or isolated description of scientific method) were deleted.

Summary

Since the publication of the theme BSCS versions in 1963, a move toward theme incorporation has been evidenced in the commercially developed *Modern Biology* series. Of the four theme categories examined, all showed a net gain in theme incorporation over time. Three had undergone substantial incorporation activity while the incorporation activity in the fourth category was so slight as to be inconsequential.

D. MATERIALS PRESENTATION: NON-TEXTBOOK FORMATTING

The Innovation

A quick glance at the elementary science programs produced with National Science Foundation support reveals that their phsycial format differs dramatically from the traditionally available elementary science programs. While each of the traditional programs consisted solely of a standard textbook geared toward classroom seatwork, a major component of the "new" curricula programs are bits of science materials and equipment that enable students to carry out scientific investigations and experiments as part of their daily classroom experience.[1]

The trend toward basing curriculum programs on manipulatives derived from the NSF science curriculum developers' conviction that first hand experience with scientific phenomena makes learning in science more meaningful to the student. They reasoned that students are better able to learn science when they actually confront selected phenomena and situations which lead them to suggest the problems to be solved and propose methods of solution. Stressing the processes of science in addition to its substantive content was seen as a means of helping the child learn information seeking strategies. And it was not enough for the child to be told about how science is "done." Active involvement in observation, hypothesis generation, measurement, etc. was thought to be central to the learning process. This notion was reinforced by leading educational psychologists whose theories stressed the importance of structured experiences for learning (Blough and Schwartz, 1969; Frost and Rowland, 1969; and Shulman and Tamir, 1973).

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[1] Varying amounts of written materials also are included in the new curricula program. The written materials tend not to be in textbook form, however, and more typically would be pamphlets and workbooks and even though there are written materials included, the programs are designed for an activity oriented classroom.

E. FORCES INFLUENCING INNOVATION INCORPORATION

The findings of the three inquiries reported in this chapter indicate that educational publishers have incorporated innovations of the federally sponsored curriculum projects into their own commercially developed programs. Moreover, the data support the argument that the incorporation of the innovations was motivated by the appearance of the innovations in the federally sponsored projects:

- *In each case, the trend toward incorporation of the innovation in commercially developed curriculum emerged after the innovation had appeared in materials developed with federal funds; and*
- *In each case the movement toward innovation incorporation peaked within several years following the publication of the federally developed materials with the innovation and then leveled off at a later point in time.*

New Curricula as Demonstration Projects

These findings would seem to corroborate the contention that federally financed curriculum development efforts have served as models of new and superior instructional approaches from which educational publishers derive ideas for the programs they develop in-house. Conceived of in this way, the new curriculum projects work out and demonstrate an improved approach to subject matter presentation that publishers eventually copy because they believe they will benefit their programs.

It is hard to deny the existence of the model programs effect. The excerpts we included showing how the history of biology theme was used in presenting concepts from genetics (p. 42-44) is typical of this type of influence. Once the BSCS texts concretely illustrated the usefulness of the narrative of inquiry approach, the *Modern Biology* publishers could, with relative ease, adopt the technique for their materials.

However, while there is some evidence of demonstration effects operating, it is necessary to question if the model programs influence is the major force influencing publishers to incorporate innovations of the new curricula into their programs. And, in fact, there is compelling evidence to suggest that other forces come into play.

For instance, when we step back to examine the rationale for the early curriculum projects we find that a major thrust of those efforts was to update the content of various high school science courses. Much of the substance and approach of the "new" curricula were not new at all, but were rather knowledge that had long circulated, but were now for the first time included in the curriculum in accordance with the new curriculum developers' commitment to revitalizing science materials and communicating an accurate picture of the current state of scientific methods and knowledge. Moreover, articles in trade journals frequently discussed innovative approaches for the presentation of science related subject matter similar to the innovations of the new curricula. Clearly the publishers of science texts were cognizant of these advances and approaches long before the publicly funded projects drew attention to them. In other words, at least some of the substantive material and approaches the commercial publishers adapted from the new curriculum projects could have been incorporated into the commercial programs at a considerably earlier point of time.

Yet, several studies of the content of science texts demonstrate that this was not the case (Del Giorno, 1969; Morgan and Koeloche, 19). New developments in science were not incorporated into textbooks until ten to thirty years after they had been announced and even when material was presented, these were usually appended at the end of the book.[1]

Moreover, the argument for a demonstration effects as motivating influences is weakened when we note that trial materials from new curcirula widely available prior to the official publication of the new curriculum programs appeared to have little influence on the incorporation of new curricula innovations into commercially developed materials. Thus, for example, even though drafts of the BSCS materials were available to *Modern Biology* publishers while the 1963 edition was being written, the publishers waited until 1965, two years after the publication of BSCS, before incorporating the BSCS innovations into the *Modern Biology* text.

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[1] Since a textbook generally includes far more information than can be covered during the school year, the majority of classes may never have been exposed to the new material.

Considerations such as these cast doubt on the proposition that demonstration effects are the major force that influence the commercial publishers to incorporate innovations of the new curricula into their own programs.

Other Forces Influencing Incorporation

In the course of this study, we became aware of three other means through which national curriculum projects acted as forces to motivate the commercial publishers to adopt various new curricula innovations. Although these forces clearly acted interactively to produce the incorporation effects, they are discussed separately below.

Market Forces. *The commercial success of the new curricula programs created market pressures that mitigated in favor of the incorporation of the new curricula innovations.*

Student usage figures for BSCS textbooks (Fig. 4) show how these forces operated in the case of high school biology. Prior to 1963 *Modern Biology* was reputed to hold 80 percent of the high school biology market. By 1964, an estimated 614.2 million students were using BSCS texts, thus reducing the *Modern Biology* market shares by at least percent. At this point the *Modern Biology* publishers became convinced that BSCS textbooks were a threat to the market success of their established commercial program and they took action to regain lost sales.

The timing of the changes in *Modern Biology* discussed previously clearly supports the view that the *Modern Biology* publishers acted in response to market strains. Even though the *Modern Biology* publishers were aware of the nature of the innovations that would appear in the BSCS textbooks prior to 1963, they did not begin to incorporate these innocations into their own successful program until it was evident that the BSCS program had created a demand at the school level for a more up-to-date curriculum. The *Modern Biology* publishers responded by bringing certain aspects of their program in line with the new curriculum programs. But they were careful not to overreact--the *Modern Biology* texts published after BSCS retained many of the features of the earlier successful *Modern Biology* editions. And as *Modern Biology* regains market stature, the amount of BSCS-like change incorporated in any one revision of *Modern Biology* appears likely to return to pre-1965 levels.

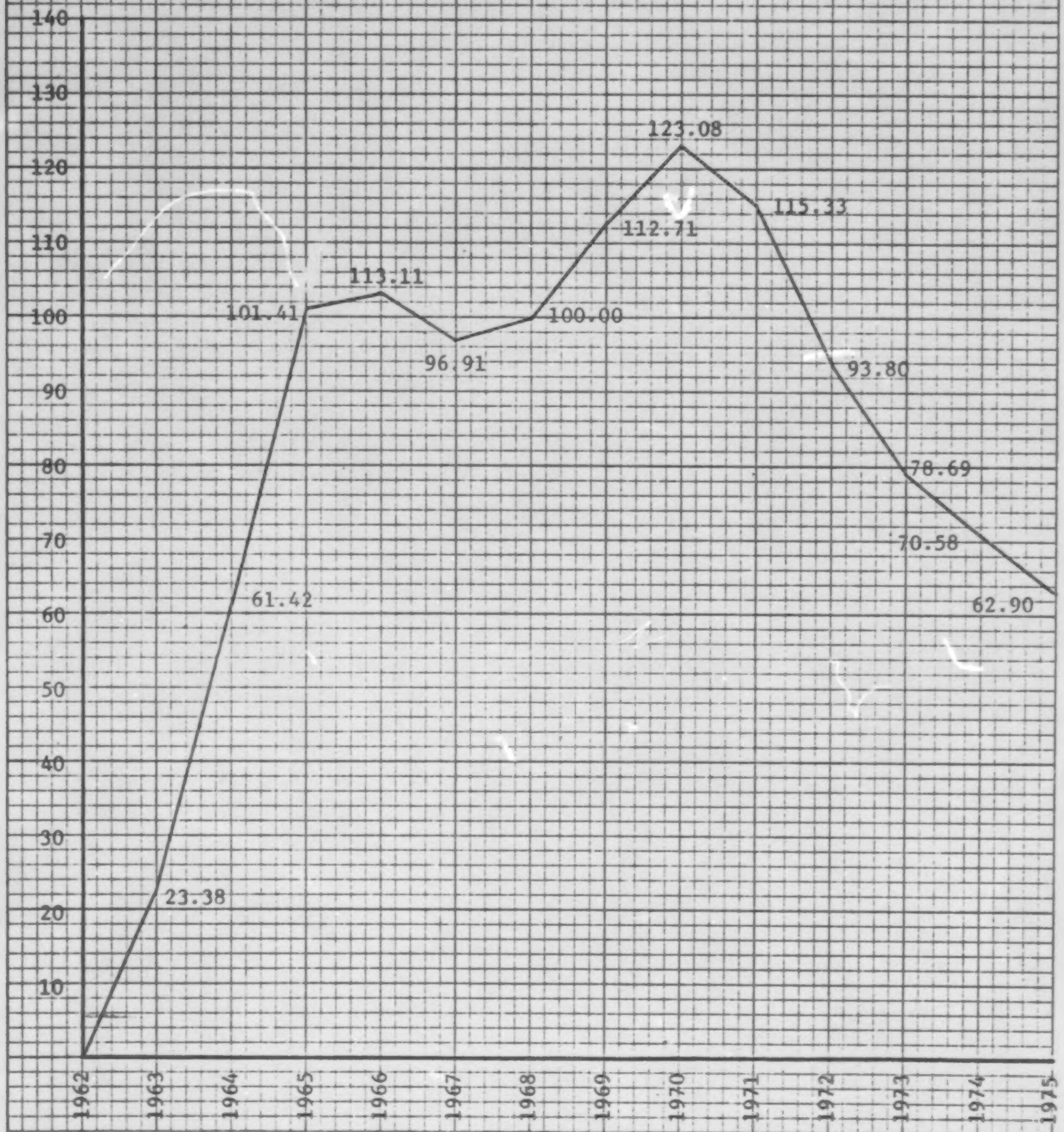

Fig. 4: Estimated Student Usage of BSCS Versions Over Time

10 X 10 PER INCH
MADE IN U.S.A.

The case of the elementary science projects demonstrates a second market force that influences curriculum change. Namely, publicly financed curriculum projects also appear to bring about innovation incorporation in commercially developed materials by generating and demonstrating the existence of new market segments and thus generating demand for certain types of programs. This change mechanism appeared to function with respect to the elementary science programs based on manipulative materials. Rather than acting primarily to disturb the market success of traditional elementary science programs, the new curricula programs seemed to contribute to a growth in demand for the teaching of elementary science. The demand for the activity-oriented programs was apparently sharp enough to convince many publishers to develop their own manipulative oriented elementary science programs.

Social and Value Considerations. Although the new curricula influenced change through market dynamics such as those described above, there were certain social and value considerations that enhanced the secondary effects of the publicly financed programs. *The proponents of the new curricula formed a powerful and well respected constituency who actively worked to bring about the acceptance of their ideas.*

The events resulting in the legitimization of the treatment of evolution in the high school biology curriculum illustrated how the change mechanism operates by demonstrating how proponents of the new curricula programs successfully challenged an established norm in such a way as to enable publishers to incorporate an innovation into the high school curriculum that had previously been considered risky and inappropriate.

Although the evolutionary concepts of biology are among the most firmly established generalizations of modern science, none of the publishers of commercially successful biology textbooks included anything more than scanty references to evolution in their textbooks prior to the release of BSCS in 1963 (Grabiner and Miller, 1974; Nelkin, 1976). In fact, Grabiner and Miller demonstrate that the much publicized Scopes Trial, generally thought of as a victory for the evolutionists, actually resulted in a decline in the teaching of evolution in the schools as judged by the content of the average high school textbook.

They attribute the superficial treatment of evolution to self-censorship on the part of the New York based publishing industry, a censorship motivated by the prevalence of state textbook adoption boards in the South, where there has traditionally been a strong undercurrent of opposition to the teaching of evolution in the schools. According to Grabiner and Miller, publishers believed that the treatment of evolution in their textbooks would result in the loss of the southern market and therefore they avoided the topic in their books.

Black (1967) reinforces this view, noting that it was not until May 1967, forty-two years after the Scopes Trial, that the Tennessee legislature finally repealed the state's anti-evolution law. He adds that at the time of his writing, Mississippi and Arkansas had anti-evolution statutes; that Hubert S. Bankston, assistant state supervisor of elementary science in Louisiana, had stated, "there is so much else of great importance to teach besides the theory of evolution, it is the part of wisdom to avoid the topic as much as possible;" and that the state commissioner of education in Alabama had maintained that BSCS books would not be used in the state's schools as long as he was in office.

The situation is quite different today. Each of the states mentioned has adopted at least one of the BSCS versions and, the post-BSCS versions of the *Modern Biology* text which, as the themes analysis indicates, include a treatment of evolution, also appear on the approved lists in __ state adoption states. In addition, recent editions of textbooks from other major publishers (see, for example, Oran et al., 1965; Smallwood and Green, *Biology*, 1974) consistently devote considerable attention to the topic of evolution and are adopted in the South.

The source of this change has been dated to the explosive 1964 textbook adoption hearings in Texas. Texas provides the largest state controlled market in the nation. Since all the textbooks the State Board approves are paid for with state funds, local schools invariably choose to use those books appearing on the state list. Thus, there was much at stake for the BSCS publishers when they submitted the three BSCS versions for adoption in 1964. The submission launched a heated controversy that pitted the anti-evolutionist fundamentalists against the BSCS proponents.

Despite bitter opposition voiced in the testimony of the fundamentalist representatives, the textbook selection committee chose to recommend that all three versions be included on the state approved list. The Board of Education sanctioned the selection committee's recommendations and in the following years nearly half the schools chose one of the three BSCS texts from among the five approved by the state (Black, 1967).

Grabiner and Miller place the Texas dispute in context:

> "Scientists participated in the hearings. The prestige, power, and financial support of the Federal Government were behind the scientists and the new textbooks. In addition, major historical changes had occurred, all militating in favor of the approval of the BSCS books in Texas: The new public interest in improving high school science teaching; the large body of legal precedents limiting religious influence in the schools; and the increasing urbanization and educational level of the people in the South. These same historical forces resulted in the repeal of the Tennessee anti-evolution law in 1967."

Thus curriculum change in a wide variety of high school biology textbooks resulted from a challenge by new curriculum proponents to a value barrier that had discouraged the inclusion of basic biological knowledge in the high school biology course. Until the new curriculum projects surfaced as a test case to challenge the omission of an important, but potentially explosive topic, publishers were unwilling to risk large losses in the southern market that they were convinced would result from the inclusion of evolution in their textbooks. Once the restrictions in key states were eased, publishers began to add more and more material on evolution to the curricula. BSCS had provided a test case which not only paved the way for the treatment of evolution in high school biology texts but actually created a situation where, according to publishers we interviewed, many biology teachers consider an absence of the treatment of evolution in a high school textbook to be a serious fault.

Institutional Change

Another way the new curricula projects promoted the incorporation of innovations into the privately developed programs was through breaking *down barriers to innovations incorporation in institutions of the curriculum policy system.*

At least two noteworthy changes of this sort emerged in reaction to the curriculum reform movement's introduction of several programs centering on manipulative materials. In the educational publishing area, the experience with manipulatives based programs resulted in publishers building the institutional capacity to develop, market, and distribute programs in a format other than the traditional textbook format. It thereby became possible for the publishers to apply this capacity to curriculum in a variety of subject matter areas and grade levels. And once this capacity was created, publishers were in a position to draw on it because of the second type of institutional change, one in the state textbook adoption area, that had resulted from activities during the curriculum reform movement. The curriculum reform movement had provided the impetus for a rethinking of what could properly qualify as a program of study in many state adoption states. This rethinking gave rise in state textbook adoption states to a trend toward a broadening of the laws to permit the consideration of basic programs in a variety of formats for state approved states. This development opened up many formatting options for the publishers who previously had been constrained because programs in any format other than the textbook format would not have been considered for adoption in areas where the textbook usage is controlled by the state.

In both these cases, the curriculum reform movement effected institutional change which, in turn, expanded the options available to those publishers who wished to incorporate innovations into their own programs. Moreover, the complementary of the changes in the two institutions point to the highly interactive nature of the curriculum policy system dynamics. Had the textbook adoption states not changed their policies and thus continued to exclude non-textbook oriented programs from consideration, there would be little reason for publishers to develop and maintain the organizational capacity to create non-textbook oriented programs. Similarly,

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[1] Chapter VI discusses these and other institutional changes resulting from the curriculum reform movement in detail and therefore these topics are treated only briefly here.

had the existence of new curriculum programs in non-textbook formats not generated considerable pressure on the state textbook adoption agencies to change their policies, it is reasonable to assume that those policies would not have been altered. In essence, the curriculum reform movement projects motivated roughly simultaneous change in the resource providing institution (i.e., publishers) and the resource regulating institution (i.e., state textbook adoption agencies) thereby adding impetus to efforts to incorporate innovations associated with the curriculum reform movement into privately developed programs.

OVERVIEW: THE BALANCE OF FORCES IN INNOVATION INCORPORATION

The Importance of Materials Incorporation. Although we only examined a small number of the curriculum reform movement innovations, the findings of the three incorporation studies provide substantial evidence of the incorporation of innovations of the federally sponsored curriculum projects into the programs of commercial publishers. The incorporation activity was most intense after the innovations appeared in the textbooks of the new curriculum programs, thus suggesting that the actual availability of materials with the innovations was a more important determinant of the publisher's incorporation activity than was the discussion of those innovations that took place for many years prior to the publication of the new curriculum materials.

These findings clearly imply that it was the existence of actual materials embodying the innovations rather than the idea that the innovations should be incorporated into educational materials that motivated the incorporation of the innovations into the programs produced by commercial publishers. In other words, making available materials with an innovation is a key factor in producing incorporation activity by commercial publishers.

Additional Factors. But the existence of materials with the innovation was not in itself enough to bring about the incorporation activity. As our analysis of forces influencing innovation incorporation suggests, the incorporation activity of the educational publishers could be understood as a reaction to a series of forces that emerged from the unusually intense interest in curriculum revision that marked the curriculum reform era. The series of events that comprised the curriculum reform movement created a situation where there appeared a large number of innovative curricula with a sizeable and often very influential set of promoters. Taken together, the programs and the promoters were in a position to exert considerable influence at several points in the curriculum policy system. This resulted in simultaneous social and institutional alterations that created a milieu in which it was far more feasible for commercial publishers to use certain innovations in their programs that it had been in the past. In other words, the curriculum reform movement projects resulted in innovation incorporation in commercially developed programs because they successfully challenged social and institutional barriers to the innovation that had existed within the curriculum policy system.

Dual Functions for Curriculum Development. In a more general context, these findings offer insights into the role of curriculum development in curriculum change. On a most basic level, curriculum change results from the ongoing incorporation of educational innovations into the curriculum materials and procedures used in the nation's classrooms. Thus, publicly sponsored curriculum development is an activity that brings about curriculum change through making available materials with innovations for classroom consumption. Cast in this light, the rationale for the support of curriculum development activities is that some public initiative is necessary for certain promising ideas to find their way into practice.

Stated somewhat differently, the rationale for support grows from the belief that there is a natural "barrier" to embodying certain apparently worthwhile ideas in forms acceptable for classroom practice. Most frequently the perceived "barrier" is seen as the inherent difficulty of translating appealing educational ideas into workable materials that embody those ideas (and anyone who has ever ventured into the world of curriculum development will attest to the challenge of the task).

However, while the translation of educational ideas from theory into materials is undisputedly an important function of curriculum development efforts, it is not necessarily the sole or most significant outcome of curriculum development activities. Another, and perhaps more important function of curriculum development arises from the impact of a project or group of projects on the institutions of the curriculum policy system. For it is these institutions that essentially determine what is taught in the schools and thereby pose the strongest barriers to curriculum change.

Many curriculum development activities perform only the first function mentioned above in that they only break down the barrier to curriculum change that separates educational ideas from concrete educational materials. While this function (i.e., the incorporation of innovative ideas into materials designed to be used in the classroom) appears to be necessary to curriculum change, it is by no means a sufficient one for assuring that materials with the innovation will be acceptable by those who directly or indirectly determine what materials are actually used in the classroom. As would be expected, it is this latter consideration that is crucial to publishers' decisions to incorporate innovations in their own programs. For unless the barriers to use are surmounted (and these barriers may exist on all levels in the policy system), it is not economically feasible for publishers to incorporate innovations into their own programs.

Taken as a whole, the national curriculum projects appear to have been distinctive in that they served the two potential functions of curriculum development. They both translated ideas into materials and also challenged social and institutional barriers to the innovations advocated that existed within the curriculum policy system.

Chapter V

INSTITUTIONAL FACTORS FAVORING MAINTENANCE OF THE EXISTING SCHOOL CURRICULUM

The primary purpose of this chapter is to identify institutional factors in the curriculum policymaking system favoring maintenance of the existing school curriculum in the dimensions in which the NSF science curriculum projects attempted to introduce innovations. These dimensions are subject matter, materials format, and classroom interaction patterns.

In order to keep the required research within bounds, our analysis is limited to three institutions. As discussed in Chapter I, the three institutions that we selected are local school districts, the publishing industry, and state adoption boards. Local school districts were selected because of their critical importance in the curriculum change process, publichers because they are the major source of new curriculum for the schools, and state adoption boards because of their direct effects on publishing.

Because of inter-organizational relationships among publishers, state adoption boards, and local school districts these institutional factors affect the school curriculum in three related ways. First, the institutional factors in state adoption boards and in local school districts limit the incorporation in the school curriculum of innovations from the national curriculum projects. Second, these same institutional factors plus others within the publishing industry limit the incorporation of these innovations in the curricula that publishers produce, since they cannot afford to invest in curricula that local school districts and state adoption boards are unlikely to accept. For this same reason, these institutional factors thirdly provide explanation of why publishers had not introduced these innovations prior to the national curriculum projects. Thus, there are three different ways that the institutional factors that will be identified favor maintenance of the existing school curriculum, which can all be summarized by showing their relationship to new product decisions made by publishers. We will summarize our findings on institutional factors favoring maintenance of the existing school curriculum in this way.

METHODOLOGY

Our approach to identifying institutional factors favoring maintenance of the existing school curriculum is eclectic and qualitative. Our primary source of information was interviews with publishers, state adoption board administrators, and the project directors and staff of the national curriculum projects described in the previous chapter plus three others.* In these interviews, we inquired about the factors in publishing, state adoption boards, and local school districts that have affected the implementation of the new science curricula and the factors that publishers more generally consider in making new product decisions. To the extent possible, the results of these interviews are supplemented with data showing differences in local adoptions of curricula containing different innovations. Adoption data is less satisfying than data on incorporation, but is much more readily available. The assumption is that differences in extent of adoption among comparable curricula are valid indicators of differences in extent of eventual incorporation.

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*These three additional projects were the Intermediate Science Curriculum Study, the Science Curriculum Improvement Study, and the Physical Sciences II curriculum.

Publishers were selected to interview according to two criteria; first, the number of NSF science curricula that they had published; and second, the number of years that they had been offering science curricula to the schools. These criteria were dichotomized into whether a publisher had either:

- o not marketed any of the NSF science curricula or two or more of them; and
- o entered the science matker within the last ten years, or more than ten years ago.

We chose the first criterion because we wanted to avoid biasing our results by interviewing only publishers who have been involved in publishing NSF programs. We chose the second criterion because we wanted to assess the affects on firms from publishing NSF science curricula, an issue that will be considered in Chapter VI. These two criteria form a two-by-two matrix of cells and we chose one publisher in each cell. A semi-structured interview form was used so that all persons interviewed were asked generally the same questions. The interviewees included the president or general manager; the marketing sales, and editorial managers; and one or more editorial staff members. Each firm was interviewed for a total of two days by one member of our project staff. In addition, we conducted pilot interviews early in the project with three other publishers. The total of seven publishers interviewed provided coverage of six of the eight national curriculum projects in which we also conducted interviews.

The interviews with state adoption board administrators were conducted by telephone. We used a semi-structured interview form, and contacted every state that has a textbook adoption board. We also site-visited the boards in California and Florida.

CHANGING SUBJECT MATTER IN THE SCHOOL CURRICULUM

In Chapter II, we concluded that a major objective of the NSF science curriculum projects was to change subject matter in the school curriculum in ways that would make the study of science more meaningful to students. These changes involved the introduction of both new subject matter areas in the school curriculum and new subject matter content within existing subject matter areas. In this section, we consider some of the factors limiting the incorporation of these changes in the school curriculum.

New Subject Matter Areas

In the category of introducing new subject matter areas, we include innovations that involve teaching subject matter that has never been taught, teaching subject matter at a different grade level than it has normally been taught, or combining existing courses into an integrated course of study. Among NSF science curricula, the TMMW high school curriculum that was briefly described in Chapter III is an example of a course involving subject matter that had never been taught, and the intermediate level Human Sciences Program is a course combining subject matter often taught in separate courses. (HSP also includes new subject matter that has neven been taught.) Other examples among the NSF high school science curricula are Physical Science II (PSII), which was a discipline-oriented course intended to combine physics and chemistry for teaching it at the 9th and 10th grade levels; the Biomedical Interdisciplinary Curriculum Project for the 11th and 12th grades, which organizes both traditional and new subject matter from the natural sciences, mathematics, and the social sciences around medical and health related topics; and, the more recent Individualized Science Instructional System (ISIS), which is a problem-oriented course intended to replace the normally separate high school subjects of biology, chemistry, and physics. To a certain extent, the elementary school curricula are also examples of new courses since a goal was to increase the priority of science as a subject at the elementary school level.

Adoption data. The introduction of a new subject matter area into the school curriculum is extremely difficult, as indicated by the data in Table __ on textbook sales for selected high school courses.[*] It is apparent from the extreme disparity in the numbers that the three curricula for which a place already exists in the school curriculum (HPP,[**], BSCS and CHEM Study) have been adopted to a far greater extent that the two curricula (TMMW and PSII) for which places do exist. Furthermore, as shown in the last column of Table __, textbook sales of the three innovative science curricula directed to existing places in the school curriculum had textbooks sales roughly proportional to total student enrollments in their respective subject matter areas at the time of introduction. Comparable data for other high school science courses are not available because they have not reached commercial availability. As also shown in Table __, the sales of TMMW have been substantially less than the curricula for which places exist in the school curriculum even though NSF

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[*] The data on textbook sales are only for the first five years after the curriculum was first introduced because textbooks are normally revised shortly after this period.

[**] HPP is the Harvard Project Physics curriculum.

Table

UNIT SALES AND IMPLEMENTATION SUPPORT FOR SELECTED NSF SCIENCE CURRICULA IN THE FIRST FIVE YEARS OF COMMERCIAL AVAILABILITY

Curriculum Project	Commerical Availability	Textbook sales (000 of copies)	NSF Implementation ($000)	Total students in subject area 1961 (000)
Subject area already existed:				
HPP	1968	220	3400	400
CHEMStudy	1962	560	1730	740
BSCS Versions	1963	1700	3900	1800
Subject area did not exist:				
TMMW	1969	26	2200	-
PSII		32	*	-

SOURCES: HPP sales data are from the publishers Holt, Rinehart and Winston. BSCS sales data are from royalty records supplied by BSCS, Inc. TMMW sales data were supplied by the publisher McGraw Hill. PSII sales data were supplied by the publisher D.C. Heath. The data on implementation are from an internal NSF study. The overall results of this study are available in U.S. House of Representatives, Committee on Science and Technology, "National Science Foundation Curriculum Development and Implementation for Pre-College Science Education," 94th Cong., Lst Session, November 1975, pp. 303-308.

NOTE: *Implementation data for the PSII curriculum are not readily available.

support for implementation has been about the same as for the three other curricula.

School District Level Factors

At the high school level, the major source of difficulty in implementing new subject matter areas has been the discipline-oriented structure of high school science departments.

One factor is that high school science teachers tend to specialize in one of the three principal science disciplines of biology, chemistry, and physics. As a result, their subject matter expertise is concentrated in their specialty and they identify professionally with it. As shown in Tables __ and __, this specialization starts with teachers' college training and carries over into their science teaching assignments. For example, of the 882 teachers in the survey on which Table __ is based who reported that they teach one course in biology, 645 answered that biology is their major assignment (i.e., that more than one-half of the courses that they teach are biology). Of the remaining 273 teachers, whose major assignment is not biology (which were called cross-discipline teachers), typically do not teach either physics or chemistry but general science, a survey course normally taken in the early high school grades by students not intending to take more science. High proportions of chemistry and physics teachers have teaching assignments in other disciplines but this is probably because student enrollments are much lower in these disciplines than in biology, which makes it necessary for them to teach other subjects. However, these chemistry teachers tend to teach biology and not physics, and the physics teachers to teach chemistry but not biology. Furthermore, the undergraduate training of these cross-discipline teachers is virtually identical to teachers whose major assignment is their specialty as indicated by the data comparing discipline and

Table

TEACHING ASSIGNMENTS OF HIGH SCHOOL SCIENCE TEACHERS, 1969

Major Teaching Assignment	Biology Teachers		Chemistry Teachers		Physics Teachers	
	Discipline	Cross-Discipline	Discipline	Cross-Discipline	Discipline	Cross-Discipline
Biology	645[1]	-	-	69	-	31
Chemistry	-	38	322[2]	-	-	88
Earth Science	-	27	-	3	-	5
Physics	-	14	-	21	176[3]	-
General Science	-	131	-	70	-	58
Mathematics	-	18	-	36	-	90
Social Science	-	7	-	3	-	8
Other	-	2	-	1	-	-
TOTAL	645	237	322	203	176	280
	822		525		456	

SOURCE: Martin Hershkowitz, "National Science Foundation Program Participation and Secondary School Science," Technical Report No. 01024.01-2, Vitro Laboratories, Silver Spring, Md., 1969, Table A-1.

NOTES: These data were obtained from a nationwide survey of over 5000 science, mathematics, and social science teachers.

[1] Of the 645 teachers whose major assignment was biology, 361 taught only biology. The others taught at least one other subject.

[2] Of the 322 teachers whose major assignment was chemistry, 121 taught only chemistry.

[3] Of the 176 teachers whose major assignment was physics, 83 taught only physics.

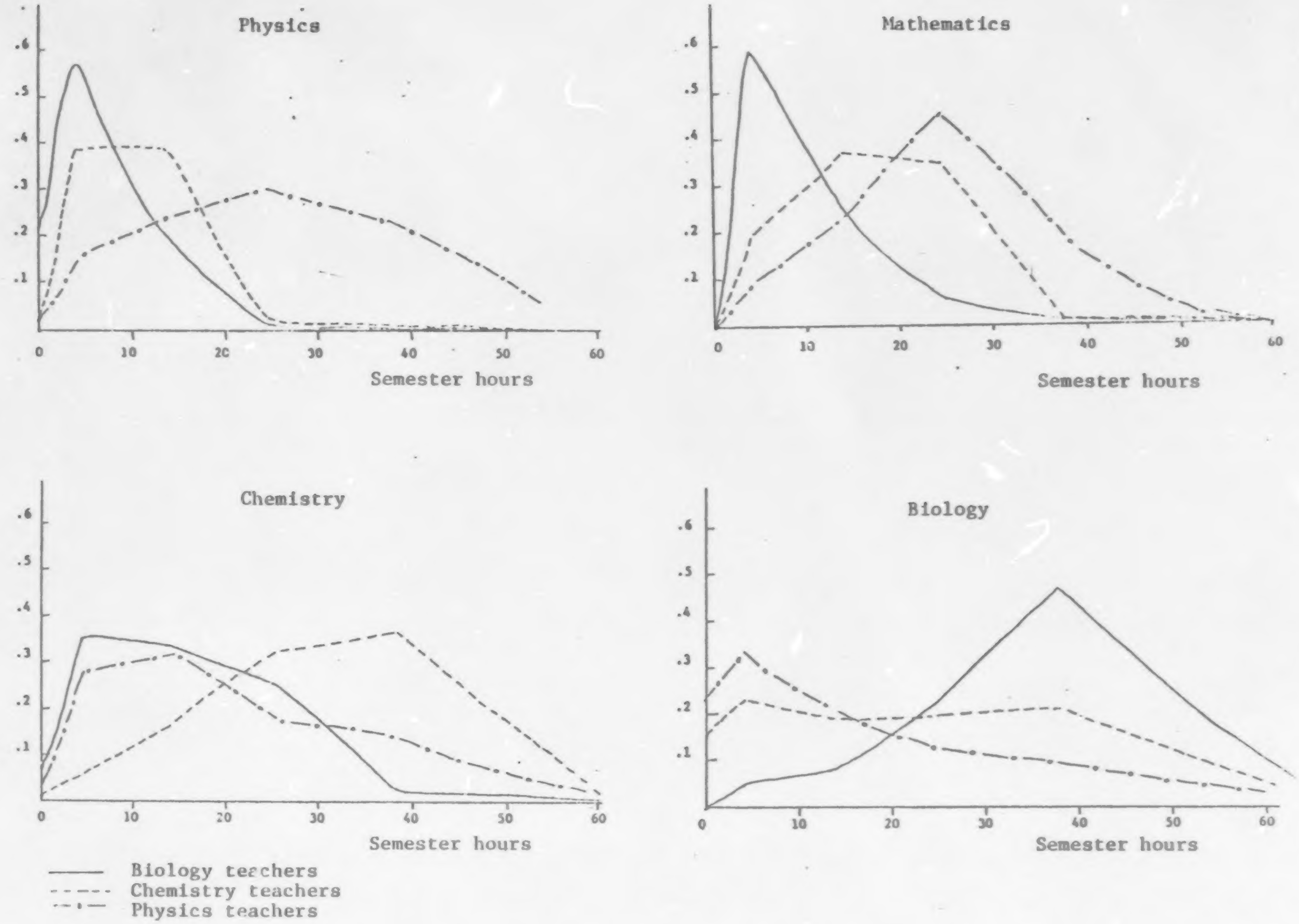

Fig. --Undergraduate coursework of high school science teachers cross discipline physics teachers in Table __. Although not shown in Table __, the undergraduate course work taken by discipline and cross-discipline teachers in biology and chemistry is equally comparable. This implies that these two populations of discipline and cross-discipline teachers are equivalent at least insofar as the subject matter knowledge that they gained in college is concerned. The consequence of this subject matter specialization for macro-implementation is that teacher support for courses like TMMW that have entirely new subject matter or like ISIS which requires teachers to cover subject matter in several disciplines is low.

A second factor is that the traditional subject matter placement of biology in the 10th frade, chemistry in the 11th grade, and physics in the 12th grade with correspondingly decreasing numbers of students enrolled (as was shown in Table __), results in the staffs of high school science departments being similarly distributed in the number of teachers in each discipline. Consequently, curriculum innovations that entail shifting subject matter to higher grade levels encounter resistance from the discipline teachers affected, out of concern that lower student enrollments will reduce the number of teaching positions. This is particularly true in biology, as has been the experience with the PSII curriculum which shifts physics and chemistry to the 9th and 10th grades, leaving room for biology only at the 11th grade or higher.[*] In conducting awareness workshops, the TMMW project staff found that physics teachers were concerned that the course would divert students who might normally take physics.

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[*] Physical Science Group, "An Evaluation of the Leadership Program and Some Aspects of Course Implementation of IPS and PSII," Newton College of the Sacred Heart, Newton, Massachusetts, March 1972, pg. 48.

A third factor is the status hierarchy in high school science departments, where typically physics teachers are the elite, often not only in the department but also the whole school. As the final science subject taken, physics is the most difficult and tends to attract only the brightest students. Although we did not find any research on the status of physics teachers, there is some indication of the status of physics teachers in the data in Table __ in that the other courses mainly taught by physics teachers are mathematics and chemistry, and less frequently biology and general science. Other data in the same study from which Table __ is drawn, show that physics teachers have typically taken an average of 15 semester hours of graduate physics courses compared to 10 semester hours of chemistry for chemistry teachers, and 5 semester hours of biology for biology teachers; and 10 semester hours of graduate mathematics compared to essentially none for the other science teachers. Many whom we interviewed said that the science department chairman is usually a former physics teacher. The consequence for changing the school curriculum is that physics teachers are reluctant to support curriculum innovations that involve moving physics to a lower grade level or integrating it with another subject.

At the intermediate and elementary school levels, there is less available data. At the intermediate level, some discipline-oriented science is taught but probably more is general science or combination courses like physical science. Thus, the factors that we have identified for the high school level are probably not as strong. At the elementary level, science is not discipline-oriented and therefore subject matter training is the only one of the three factors at the high school level that is potentially important. A nationwide study of elementary science teaching has found that the average elementary science teacher has taken an average of only 17 semester hours of undergraduate science courses (with a standard deviation of 15 semester hours),[*] which is much less than the levels for high school science teachers shown in Table __. However, in another part of this study teacher useage of new science curricula was correlated with the number of semester hours of undergraduate training in science along with a large number of other factors. The result was that college coursework is not an important factor in that it is uncorrelated with useage. Therefore, at least on the basis of this study, it cannot be concluded that lack of college preparation is an important factor in the implementation of the new elementary science courses.

In considering investments in the development of new programs, publishers face these same three factors of the subject matter preparation of teachers, the grade-level placement of science courses, and the status hierarchy in science departments. As indicated by the data in Table __, and the interviews that we conducted these factors are strong enough that publishers essentially take the existing structure of subject matter areas as given and only develop courses within this structure.

New Subject Matter Content

As described in Chapter III, another kind of innovation advanced by the NSF science curriculum projects was to change the content emphasis within existing subject matter areas. Because the discipline oriented structure of school science is not affected, the factors affecting the incorporation of this innovation are different.

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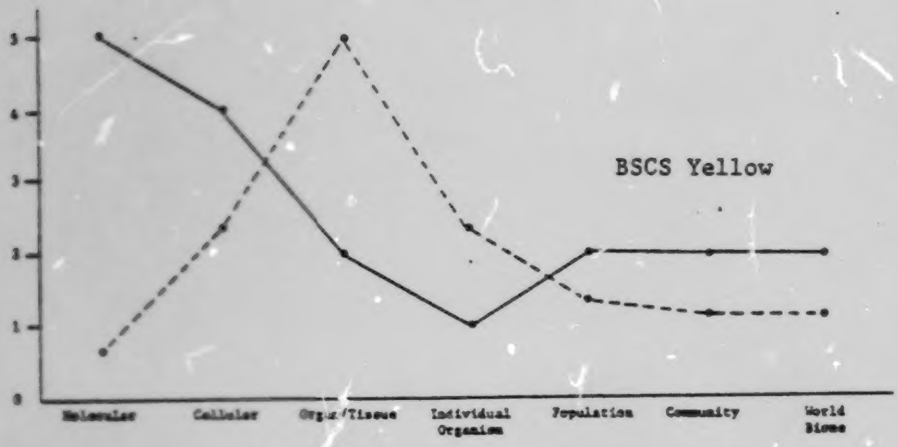
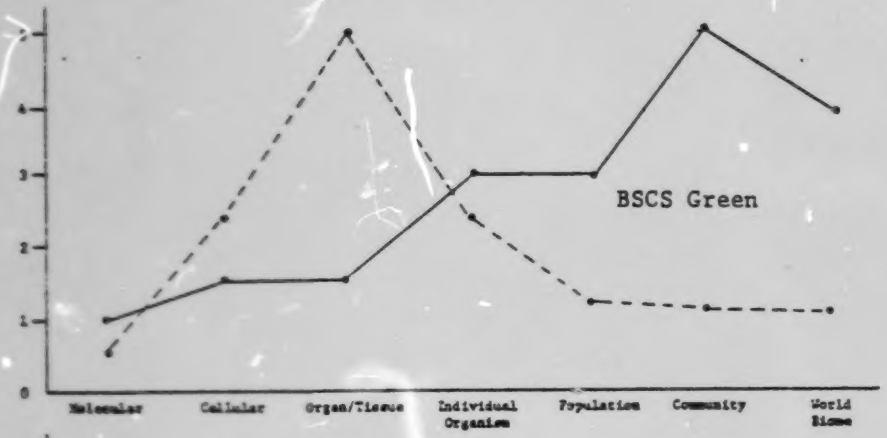
[*] Robert Steiner, et. al., "A Survey of Science Teaching in Public Schools of the United States (1971)," Volume 4 - Elementary Schools, ERIC Science, Mathematics, and Environmental Education Clearinghouse, Ohio State University, Columbus, Ohio, 1974, Table 8.

Adoption data. The task of determining the content emphasis of a curriculum is so complex and requires so much research effort that it is impossible in this report to present data on a large number of projects showing the extent to which changing subject matter content affects macro-implementation. However, as an illustration, some available data indicating the relationship can be shown for the BSCS curriculum.

BSCS is a particularly good example because the three textbooks that were produced were similar in most respects except for different content emphasis, and because there was one conventional textbook that dominated 10th grade biology. As shown in Figures ___, ___, and ___, the Blue Version emphasized the molecular and cellular levels of biological organization, the Green Version emphasized the population, community, and world biome levels of biological organization. The Yellow Version emphasized the cellular level but was closest to the conventional text in subject matter content in that content at the molecular and the population/community/world biome levels represented the most innovative content in relation to the conventional curriculum. Although not strictly valid because of the way that relative emphasis was defined in compiling these data, the total absolute differences between the subject matter content of Blue, Yellow, and Green Versions and the conventional text are respectively 13, 12 and


BSCS Yellow
0
1
2
3
4
5
Molecular
Cellular
Organ/Tissue
Individual Organism
Population
Community
World Biome


BSCS Green
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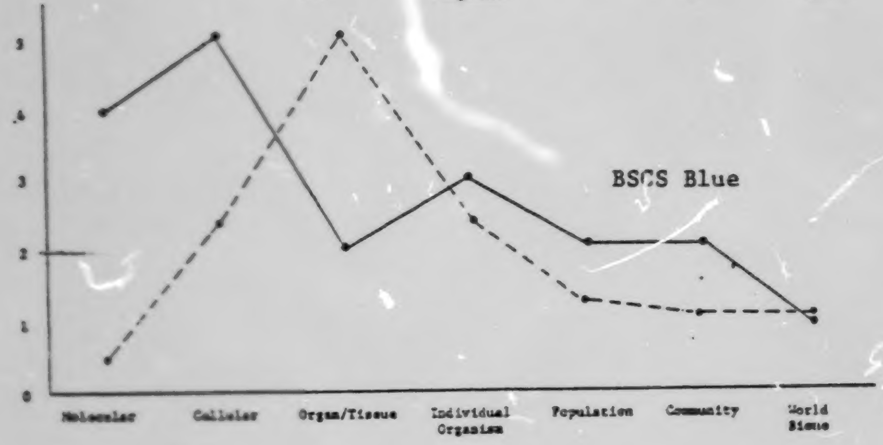
Cellular
Organ/Tissue
Individual Organism
Population
Community
World Biome


BSCS Blue
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1
2
3
4
5
Molecular
Cellular
Organ/Tissue
Individual Organism
Population
Community
World Biome

15[*] as measured by simply adding the differences between the Versions and the conventional text for each level of biological organization. Weighting the molecular and the population, community, and world biome levels more than the other levels would increase the differences among these measures. The Yellow Version is also more similar to the conventional text than the Blue and Green Versions in that the major chapters are divided according to the traditional, biological subfields of microorganisms, plant life, and animal life, and so forth,[**] while the major chapters in the other Versions follow the BSCS conceptual themes more closely. Yellow is believed by the BSCS staff to have been the closest of the three Versions to the content of the conventional program.

As shown in Table __, the initial textbook sales of the three BSCS Versions parallel the extent to which their content departs from the conventional text, which we are using as a proxy for the traditional secondary biology curriculum. The main discrepancy is that the Green Version outsold the Blue Version eventhough the measures that we calculated indicated that the Green Version is further from the traditional curriculum than the Blue Version. One plausible interpretation of this discrepancy are that teachers and local curriculum selection boards decided that the ecological content of Green was potentially more interesting to their students then the biochemical content of Blue. Another is that teachers were more confident of being

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por—, —, and —, "relative emphasis" is only the
k pages devoted to a particular level of biological
orgered to the portion devoted to the particular level
havges. Therefore, comparisons among texts are not
strcept to the extent that different texts have equal
pagfact, the Versions and the conventional text are
appl in page length.

:hwab, "Biology Teachers Handbook," op. cit

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Table

TEXTBOOK SALES OF THE BSCS VERSIONS AND THE CONVENTIONAL TEXT IN THE FIRST FIVE YEARS OF COMMERCIAL AVAILABILITY OF BSCS VERSIONS (thousands of copies)

Textbook	Unit
BSCS Version	1770
Blue	400
Yellow	850
Green	520
Modern Biology	2100

SOURCE: Royalty data supplied by BSCS, Inc., and sales data supplied by Holt, Rinehart, and Winston.

able to teach the ecological content of Green than the biochemical content of Blue because of their subject matter background in biology and zoology.

Teacher's subject matter knowledge. Nevertheless, the lower number of adoptions for Blue and Green as compared to Yellow correlates with their more extreme subject matter content, indicating that this is an important factor in explaining adoptions. In fact, these data show that the small differences between the Yellow and the Blue and Green Versions apparently resulted in about a factor of two difference in initial adoptions. We looked for studies directly measuring the correlation of teacher's subject matter knowledge and adoption of a new science curriculum but did not find any.

In developing new programs or revising old ones, publishers consider including the subject matter content expected by teachers to be one of the most important factors, even down to the level of certain topics that must be included for a curriculum to have a chance of selling. In developing a new curriculum publishers may try to find a new way of organizing subject matter that will be more attractive to teachers but care is typically taken to include the subject matter that in their experience teachers expect. In revising programs, very few changes in subject matter emphasis are typically made as will be illustrated in Chapter V for the Modern Biology program. The issue regarding the importance of subject matter content is not whether there are curricula on the market that differ substantially in content, because in most subject areas there are, but what the differences are in subject matter content of the most successful programs and the number of instances in which a publisher has been highly successful with a program having substantially different subject matter content than the previously more successful programs, no matter what the differences are in organization of content into chapters and paragraphs.

More information on this issue of the relationship of teacher's familiarity with subject matter to curriculum change is needed, because of its importance to federal macro-implementation strategy. To the extent that teachers' subject matter knowledge is significant then the importance of either formulating long-run policies to change science courses in colleges of education or in the short run, to emphasize subject matter training in science programs is increased. In fact, NSF's early teacher institute program was directed mainly to upgrading teacher's knowledge of subject matter and an assumption was that this would result in greater receptivity to and success with the new science curricula.

Priorities of State Adoption Boards. Another important factor limiting change is the subject matter priorities of state adoption boards. The mechanism is that when the subject matter content of an innovative curriculum is not consistent with a state's priorities, it may be disapproved for use within that state, reducing usage of that curriculum and hence incorporation in the school curriculum.

Most state adoption boards formally state their priorities in the form of curriculum guidelines that are used in review processes and issued to local school districts for their use in planning. The specificity of these guidelines varies by states but in some states are highly specific. One example is California, where the State Curriculum Commission (which is the formal name of the state adoption board) produces what are called "curriculum frameworks" that are highly detailed both with regard to the content strands that should be covered by grade level and even the topics within those strands.

For example, in elementary mathematics, the strands in 1975 were: (1) arithmetic, numbers, and operations; (2) geometry; (3) measurement; (4) problem-solving and applications; (5) statistics and probability; (6) logical thinking; and (7) relations and functions. Within each of these strands there are substrands, and within these substrands 10 to 40 specific topics to be covered by grade level.

In most states, the actual decisions on what curricula will be approved are made through highly complex and political processes involving reviews by state adoption board staffs and committees of teachers and local curriculum supervisory staff, with final approval by the board itself. The membership of these boards varies in that some are predominately composed of professional educators and others the general public. The subject matter content preferences of the participants, which in individual cases may or may not be affected by the priorities of any curriculum guidelines used, combine in complex ways to affect the outcomes and consequently the innovative programs in those states.

Publishers obtain and refer to the curriculum guidelines produced by the state adoption boards as a major source of information on curriculum priorities in making decisions on the content structure of new programs and in revising old programs. As will be discussed below, publishers have other sources of such information but the accessibility and visibility of the boards makes them a key source. Occasionally a state's guidelines are considered good enough and sufficiently balanced in approach that a publisher uses them as the outline for a course to be produced. Generally, however, the differences in the curriculum philosophies and the content specified in the guidelines are great enough that choices must be made regarding what to include and what to exclude in order to produce a coherent curriculum. Information from salesmen in the states on what content in the guidelines is most important are considered in this decisionmaking process.

A few of these states have much greater influence on publishers than the others because of the size of their school populations, the specificity of their guidelines, and detailed features of their adoption and contracting procedures, which affect the costs to publishers of winning an adoption and hence profits. From our interviews with publishers, two of the most influential states are California and Texas, with others often mentioned including Florida and North Carolina. As shown in Table __, the market shares in Texas and California are respectively 7.1 and 6.5 percent. The significance of these market shares can be illustrated by the example of a publisher who is about to invest in a new curriculum expected to gain a 20 percent share of the national market. Winning either the Texas or California adoption with that program has the potential of increasing sales by about 35 percent, which because development costs are fixed can add substantially to profits. Actual profits are usually lower than this potential amount because some school districts may chose one of the other programs adopted and because there is still the expense of selling the program against other competitors who won the adoption. But, the competition is limited to the curricula that have been adopted by the state. Publishers pay close attention to the politics of adoption in the key states, influence those politics, and learn tactics for selling their programs to the schools

2)

ESTIMATED EL-HI PUBLISHERS' SALES TO STATES WITH ADOPTION BOARDS

(millions of dollars)

Adoption States	Elementary		Secondary	
	dollars	percent	dollars	percent
Alabama	3.6	.9	3.3	1.4
Arizona	5.3	1.3	-	-
Arkansas	4.4	1.1	2.6	1.1
California	26.8	6.5	-	-
Florida	11.0	2.7	6.5	2.8
Georgia	8.2	2.0	4.6	2.0
Idaho	1.5	.4	.9	.4
Indiana	8.8	2.1	5.0	2.1
Kentucky	5.7	1.4	3.6	1.6
Louisiana	5.1	1.2	3.1	1.3
Mississippi	4.3	1.0	1.9	.8
Nevada	1.3	.3	.6	.3
New Mexico	1.5	.4	1.2	.5
North Carolina	22.0	5.4	9.2	3.9
Oklahoma	4.8	1.1	3.0	1.3
Oregon	9.9	2.4	5.2	2.7
South Carolina	5.5	1.3	2.9	1.3
Tennessee	5.2	1.3	5.0	2.2
Texas	29.0	7.1	16.0	6.9
Utah	2.4	.6	1.3	.6
Virginia	11.4	2.8	5.4	2.3
West Virginia	2.0	.5	-	-
TOTAL	180.3	43.9	81.3	35.0
ALL STATES	411.0	100.0	232.0	100.0

SOURCE: "Industry Statistics, 1975," Association of American Publishers, New York, 1976, Table F5b.

once they have won a competition. In some states there are political dynamics that make it possible to sweep an adoption eventhough other publisher's programs have been approved. Salesman assigned to areas including adoption states are responsible for knowing who the influential figures in curriculum are in the state and the directions of curriculum change.

From the adoption board's point of view, it is not advantageous to produce guidelines that are too far out of line from the content of existing textbooks and modal teaching practices in the state. Otherwise there will not be many alternative curricula that qualify for adoption, and local personnel preferring the programs excluded will be displeased. Thus, the priorities of the boards tend to reflect the content of existing textbooks and existing regularities in the school curriculum, rather than to strongly lead curriculum change. Also, the state staffs communicate and exchange copies of guidelines that they produce with their colleagues in other states, further tending to make priorities similar from state-to-state.

The overall effect of these reciprocal relationships between publishers and state adoption boards, between the boards and local district staff, and between different boards is that the subject matter priorities in the adoption states tend to be similar and to reflect the modal preferences of teachers within those states, with certain key states being more influential than others in the priority setting process. Or, in other words, the institution of state adoption boards is a force tending to maintain the existing school curriculum. And because publishers cannot afford to develop different curricula for different states, the effect of these adoption states on priorities is nationwide and not only in the adoption states.

Limits on Number of Approved Alternatives. Another factor reinforcing maintenance of the existing school curriculum are the policies of state adoption boards limiting the number of curricula that will be approved in each subject area. When NSF first began to support national curriculum development, some states limited approvals in some subject matter areas to a single alternative, with several other states having a limit of five or less, as shown in Table __. Limits in major subject areas like elementary reading were sometimes slightly higher, as in California where elementary science was limited to one and reading to four alternatives.*

Limits on the number of approvals have the effect of forcing the selection of curricula that will meet the priorities of a majority of local school districts and teachers within a state, since approval of programs appealing to small numbers of teachers would preclude chosing programs preferred by the majority. Clearly, the lower these limits are, the greater the effect is on subject matter priorities within a state and, in turn, on publishers and the nationwide school curriculum. With only one or two alternatives, the effect is even stronger than maintenance, since the alternatives selected will tend to reflect only modal priorities. This tends to produce convergence to these modal priorities and to supress diversity.

SUMMARY

In summary, among the institutions in the curriculum policymaking system that we examined, there are four main factors that affect the incorporation and hence decisions by publishers regarding changes in the content of their programs: the subject matter preferences and knowledge of teachers, the compartmentalized structure of the teaching staff (mainly in high schools), the subject matter priorities of state adoption boards, and the policies of state adoption boards limiting the number of curricula that will be approved in each subject matter area. These factors and their relationship to new product decisions made by publishers are diagrammed in Fig. __. These factors explain some of the difficulties in implementing the subject matter innovations in the new NSF curricula and affect publishers' decisions in ways resulting in each generation of curriculum following from the previous one and for the content of curricula produced to tend to converge to the modal priorities of a few key states.

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*Texas used to limit approvals to a single alternative. Thus, in past years, a publisher winning an adoption in both of these states was guaranteed about 14 percent of the total market in a subject area.

Several other factors that we did not investigate may also be important and have similar effects. First, we did not carefully consider the adoption boards in many local school districts which function very similarly to state adoption boards and therefore probably have similar effects. Publishers pay as close attention to these boards in the larger cities as they do to the boards in the key adoption states. Another possibly important factor is the content of tests published by testing organizations for use in local school districts. In interviewing publishers, we inquired about the extent that publishers refer to tests in selecting content for their programs and found that with rare exception they do not. Thus, if testing influences the school curriculum, the effect is mainly through decisions made at the local and state levels. Another factor, possibly important in the introduction of new

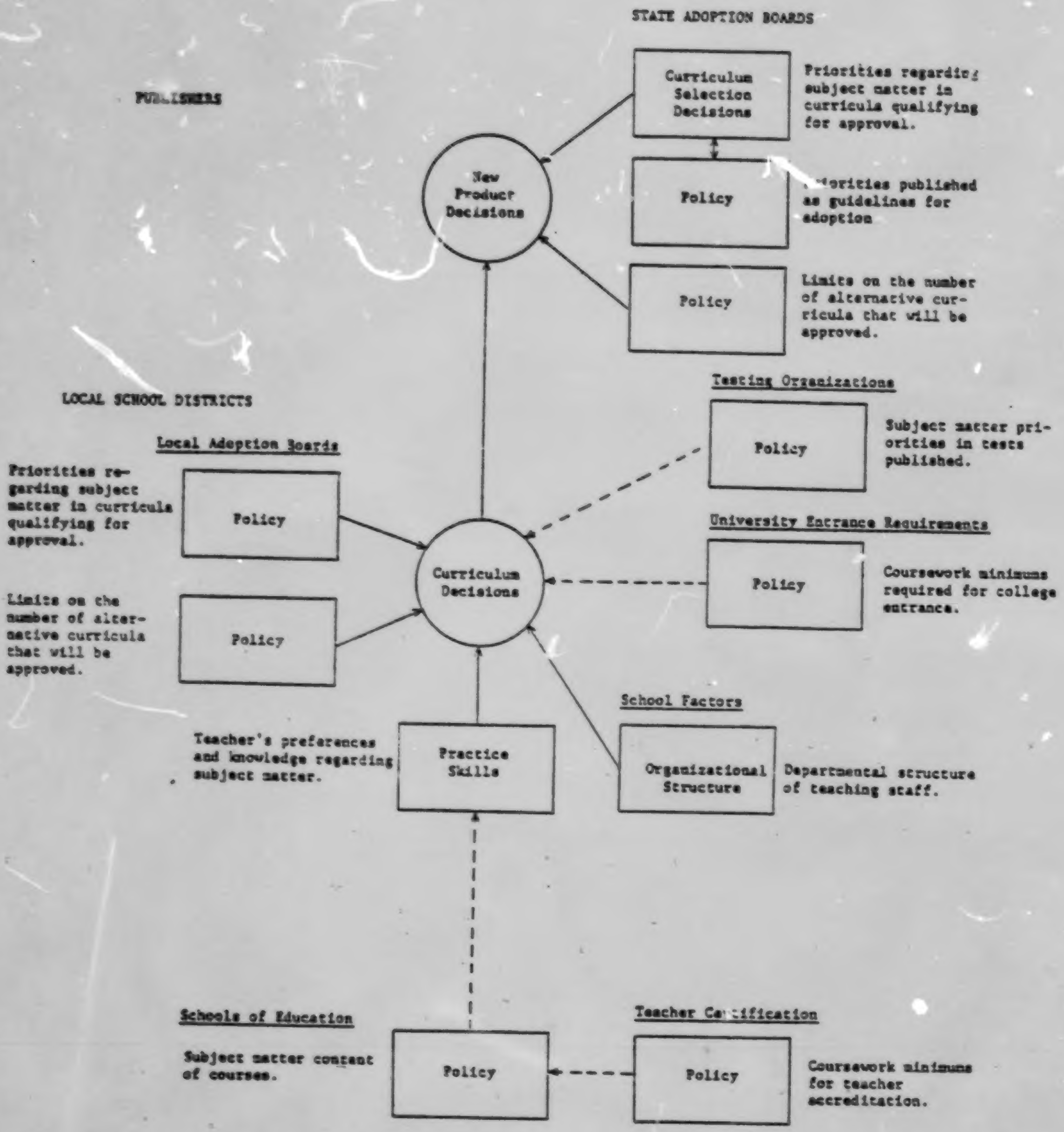
PUBLISHERS
STATE ADOPTION BOARDS
Curriculum Selection Decisions
Priorities regarding subject matter in curricula qualifying for approval.
New Product Decisions
Policy
Priorities published as guidelines for adoption
Policy
Limits on the number of alternative curricula that will be approved.
LOCAL SCHOOL DISTRICTS
Local Adoption Boards
Priorities regarding subject matter in curricula qualifying for approval.
Policy
Limits on the number of alternative curricula that will be approved.
Policy
Curriculum Decisions
Testing Organizations
Policy
Subject matter priorities in tests published.
University Entrance Requirements
Policy
Coursework minimums required for college entrance.
Teacher's preferences and knowledge regarding subject matter.
Practice Skills
School Factors
Organizational Structure
Departmental structure of teaching staff.
Schools of Education
Subject matter content of courses.
Policy
Teacher Certification
Policy
Coursework minimums for teacher accreditation.

Fig. —Institutional factors favoring maintenance of existing subject matter in the school curriculum subject matter areas, is the coursework required of students by universities for college entrance. Lastly, there are possible effects of teacher training on the school curriculum through affecting the subject matter knowledge and preferences of teachers, which we partially considered. Careful consideration of these factors along with others suggested by the list of institutions affecting the school curriculum in Chapter II, might greatly increase the complexity of interrelationships affecting change in the subject matter of the school curriculum and reinforce the tendencies to convergence and stability.

NEW FORMAT OF MATERIALS

In Chapter II, we also discussed how the ideas in the science curriculum projects for emphasizing concrete manipulation of the natural environment entail shifting from textbooks to enactive materials in the school curriculum. In this section we consider some of the factors that make incorporation of this change in the format of materials difficult.

Organizational Capacity of Publishers

There are four major institutional factors in publishing impeding the incorporation of the enactive materials innovation. All of these factors concern the lack of organizational capacity in el-hi publishing for producing and distributing non-print materials.

Manufacturing Costs. One factor in publishing affecting the incorporation of enactive materials is that the dominance of print media means that there is practically no capacity in the el-hi publishing industry for producing and packaging curricula based on enactive materials.

Traditionally, publishers have not maintained their own production capacity bu contracted for books as needed with printing firms. These firms have acquired highly automated printing presses and worked out efficient production techniques for performing the steps of printing, cutting, collating, and binding so that books can be produced for very low cost. When the NSF elementary science curricula were introduced, no comparably efficient capacity for manufacturing programs based on enactive materials existed within the el-hi industry.

Assembling the enactive materials beeded in an elementary science program is a difficult task. One problem is that suppliers have to be found for each of the many hundreds to thousands of parts in a program heavily based on enactive materials. These materials may include items as diverse as wooden blocks, plastic counters, seeds, chemicals, glassware, scales, metal objects, containers of various kinds, mirrors, light sources, lenses, and all kinds of living organisms. In addition, printers have to be found for myriad cards and worksheets, teachers guides, and other paper material. Then all of these components have to be assembled into kits for shipment. All these steps have to be performed for a total cost that is competitive with the cost of producing a book or the program will not sell. Considering that the manufacturing cost to a publisher of a book is between $1.00 and $1.50 that each student in a class will have a book, and that the average class size is 30, this competitive cost is about $30 to $45 per classroom.[*]

The problem for publishers in deciding whether to offer a textbook or manipulative materials-based program is choosing between a format where reliability of delivery is certain and manufacturing costs are low and easily estimated, and a format where reliability is uncertain and costs can quickly get out of control. Facing these uncertainties the incentives to continue with textbook programs are very strong until individual firms establish new production technology and techniques, supplier firms emerge, and enough experience is gained with programs incorporating enactive materials that cost become more certain and may decline.

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[*] The approximate cost for a 320 page, cloth-backed book containing about 1 half-tone picture per page, with 50 lb. paper, and printed in a quantity of 20,000 is $1.20.

Distribution Costs. In addition, programs based on enactive materials are difficult to distribute to the schools. Instead of textbooks, which can be easily inventoried, boxed, and shipped, programs based on manipulative materials may consist of many different kits, separate teachers guides, films and film tapes, and other extras, each of which can be ordered spearately or in any combination by a teacher or a school district. Furthermore, an inventory of each of the separate parts has to be maintained to fulfill replacement requests. What the demand for replacement parts will be is initially unknown so ample inventories have to be maintained. Replacements are usually ordered pm a short lead time, and therefore publishers have to respond quickly or risk loosing customers because of bad service. And there are special problems in finding ways of making sure that live organisms are delivered alive and not to the unloading dock on Friday after the close of school. Solving all these problems is a difficult organizational challenge for publishers.

Selling Practices. A third factor is that curricula based on manipulative materials are inconvenient for salesmen to handle on their rounds in contacting teachers and administrators in local school districts. Instead of packing a book for each course in the product line into a suitcase, a salesmen has to lug around a kit and maybe several packets of teachers guides and student materials. This complexity makes it difficult for the salesmen to explain a program in the few minutes that they are used to spending with each of the people whom they contact, leaving little time for selling other products. Furthermore, salesmen may not understand the purposes and teaching methods of the new programs as well as traditional textbook programs, making them even more difficult to explain. Top management may have a difficult time convincing salesmen to make the necessary extra effort to sell a program based on enactive materials when selling a textbook is so much easier.

The sales forces of el-hi publishing firms are important because they may be one of the most effective dissemination mechanisms operating in education. In having responsibility for a territory, these salesmen gain detailed knowledge of local school districts through spending much of their time meeting face-to-face with administrators and teachers. One study of science curriculum innovation in a state has found that 42 percent of teachers rate textbook salesmen as their "most important" source of information on new programs, followed by teaching colleagues at 24 percent, professional journals at 19 percent, science associations at 7 percent, state science staff 1 percent, and other 7 percent.* Comparable results have been found in a well known study of medical innovation.* In this study, 38 percent of doctors rated salesmen from drug companies to be their "most important" source of information on new drugs, 23 percent journal articles, and 20 percent from colleagues and meetings.

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*James Michael Grahm, "A Field Initiated Study for the Improvement of Secondary School Science Instruction in Minnesota," MS thesis, Bemidji State College, Bemidji, Minnesota, June 1974. Whether the "importance" of these sources varies by types of curriculum innovation, or whether textbook salesmen are "most important" in the sense of providing only initial awareness of curriculum innovations, or in the sense of convincing them to adopt an innovation is not clear from this study.

Copyright Law. Finally, existing copyright laws do not apply to enactive materials so that publishers cannot prevent other firms from simply copying these materials and offering them to the schools at lower cost. This reduces the incentives for publishers to invest in the development of their own programs based on enactive materials and further discourages their salesmen since they stand a chance of making a sale and then finding out that someone else fills the order. In the cases of both ESS and SCIS, firms have come into the market offering less expensive materials. Unlike the ESS and SCIC publishers, these firms do not pay royalties to NSF.

Policies and Procedures of State Adoption Boards

In the institution of state adoption, there are two major factors limiting the incorporation of the enactive materials innovation. Both of these factors are weaker today than they were 15 years ago at the beginning of the curriculum movement, for reasons that will be discussed in Chapter VI.

Textbook Only Policies. One limiting factor is that prior to the curriculum movement no state adoption board permitted the approval of non-textbook curricula. In some states this policy was written into the law while in others it was an unwritten rule. Furthermore, in most of these states, the policy was that only hard-backed and not paper-backed textbooks would be approved. As shown in Table ___, the effect was that

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*James S. Coleman, et al., *Medical Innovation Diffusion Study*, Bobbs-Merrill, Indianapolis, 1966, p. 61.

curricula based on manipulative materials could not be sold in approximately 44 percent of the elementary market and a somewhat smaller proportion of the high school market.

Sampling Procedures. Even if these policies had not been in force, there was the further problem that the adoption regulations in most states required that publishers supply at least one copu of the entire curriculum to each member of all review committees and it was not unusual to require that sample copies be distributed to all local school districts on request. In addition, several adoption states and many local school districts having adoption boards require that publishers pilot programs being offered for adoption in a number of schools, as a step in the review process. While the cost to publishers entailed by these regulations is reasonable for textbook programs, the expenses for curricula based on manipulative materials can run to tens of thousands of dollars for each adoption. For example, one complete set of all ESS units costs over $4000,* and occupies a bulk of several cubic feet. Setting up a pilot program in one school can easily cost $5000 for the program based on manipulatives, as compared to a few hundred dollars for a textbook program.

Materials Support Capability in Local School Districts

A fifth factor, mainly important at the elementary level, is lack of organizational capacity in school districts to support the usage of science curriculum employing manipulative materials. The problem is that since elementary science has traditionally been taught from textbooks and has not been an important subject, few school districts have hired supervisory staff for coordinating materials supply, developed the capacity to inventory these materials, provided space for science activities, nor established budgets high enough to allow purchase of sufficient materials. With textbook programs, the materials can be ordered once and typically last for several years, are easily managed in the classroom by teachers, do not require special space, and cost only about one dollar per year per student. With programs based on manipulative materials, individual items have to be periodically replaced as they are lost or consumed (or taken home by the students), apparatus may break down or malfunction requiring repair, open work space must be provided, and purchase costs are about twice as high.

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*A teacher would normally use only a few of the total 56 units in a given year.

Although publishers' experience has been that these organizational factors are important in explaining the incorporation of the manipulative materials innovation, research data are hard to find. In one study that we found of the usage of NSF's new science curricula in one state, a result was that districts where at least one of these curricula are being used are about four times more likely to have an elementary science coordinator, one-and-a-half times more likely to have specialized science teachers, and two-and-a-half times more likely to have centralized support for purchasing and other administrative functions than school districts not using any of these curricula.* But no attempt was made in this study to determine exactly how these factors contributed to the implementation of the new science curricula. In another study that we found, which was an evaluation of a state-wide program for implementing the new elementary science curricula, a conclusion was that equipment and materials supply is the major constraint[*] on successful usage. The only other study that we found concerned the implementation of the USMES program in two school districts. USMES has largely failed to persist in these two school districts and one factor was lack of administrative support to provide the necessary space for the Design Lab.[**] Only isolated groups of teachers in these two districts remain highly committed to the program.

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*Dean K. Whitla, "Essentially Elementary Science; A Report on the Status of Elementary Science in Massachusetts," Graduate School of Education, Harvard University, Cambridge, Massachusetts, March 1973, p. 109. The data in this study are based on a questionnaire survey of 214 local school districts in Massachusetts.

Summary

In summary, among the institutions in the curriculum policymaking system that we examined there are three main factors favoring macro-maintenance of textbooks as the dominant format of materials used in classrooms: lack of organizational capacity in the el-hi publishing industry for producing, distributing, and selling curricula containing enactive materials; the policies and procedures of state adoption baords restricting approvals to only textbook programs, and the lack of organizational capacity in local school districts for providing materials support to teachers. These factors and their relationship to new product decisions made by publishers are shown in Fig. __. Each factor is an influence on publishers to continue with the textbook format and not to change to enactive materials.

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[*] Ronald D. Anderson and Jerry Horn, "Diffusion of the New Elementary Science: An Assessment of One Model," *Science Education*, Vol. 56. No. 3, pp. 317-327.

[**] Wayne W. Welch and William H. Ward, "Evaluation of USMES Implementation Projects," Minnesota Research and Evaluation Center, University of Minnesota, Minneapolis, Minnesota, September 1975.

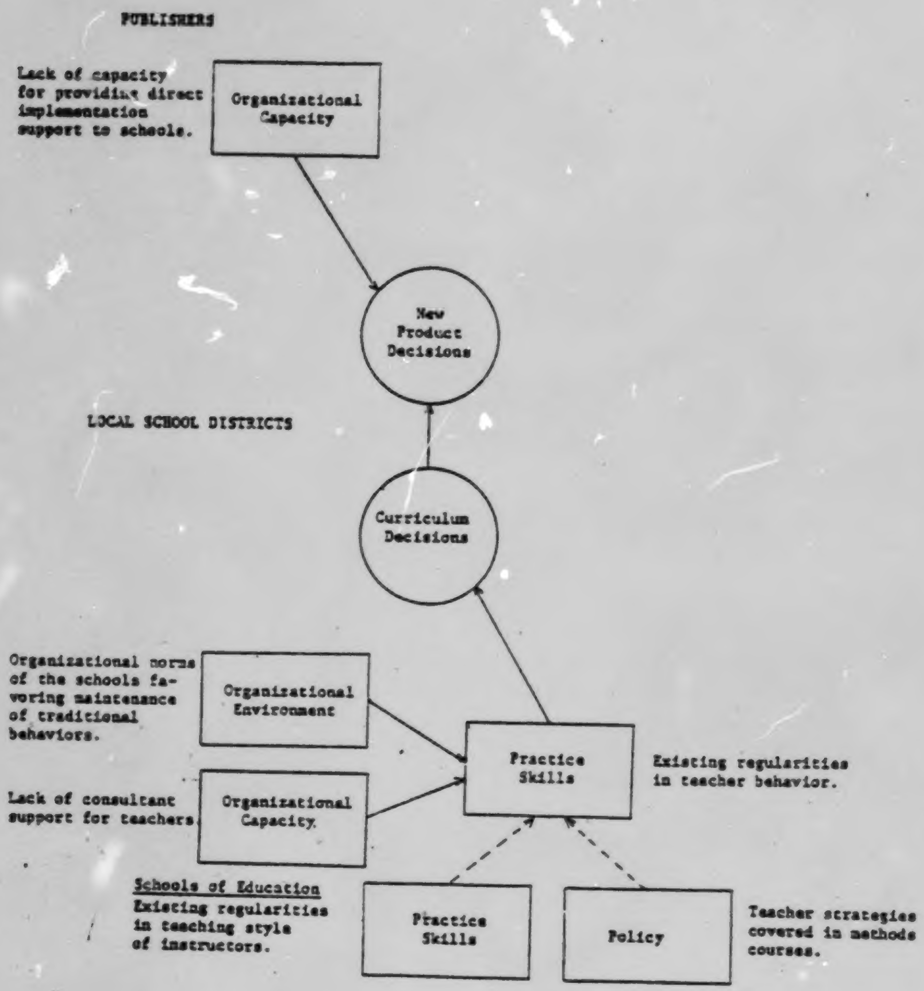
PUBLISHERS
Lack of capacity for providing direct implementation support to schools.
Organizational Capacity
New Product Decisions
LOCAL SCHOOL DISTRICTS
Curriculum Decisions
Organizational norms of the schools favoring maintenance of traditional behaviors.
Organizational Environment
Practice Skills
Existing regularities in teacher behavior.
Lack of consultant support for teachers.
Organizational Capacity
Schools of Education
Existing regularities in teaching style of instructors.
Practice Skills
Policy
Teacher strategies covered in methods courses.

Fig. —Institutional Factors Favoring Maintenance of traditional classroom interaction patterns

The significance of these factors is that extensive incorporation of the enactive materials innovation at the classroom level apparently requires, or at least would be greatly facilitated by incremental organizational changes in all three of the institutions that we considered. But there is very little incentive for any individual organization in these three institutions whether a school, state adoption board, or publisher to make these changes unless enactive materials are extensively used in classrooms. A potential effect of the NSF's new science curricula incorporating enactive materials is to cause these changes to begin to occur. Then the incentives for publishers to introduce their own programs based on enactive materials would be increased.

NEW CLASSROOM INTERACTION PATTERNS

Finally, we also described in Chapter II that the ideas for presenting subject matter in ways that are more meaningful to students and shifting to enactive materials entail changes in classroom interaction patterns. In the new science programs, students are supposed to work individually or in small groups and to have more freedom to choose what subject matter they investigate than in conventional classrooms. These changes require that teacher's must shift their role from the traditional mode of lecturing students and asking fact-recall-oriented questions to supporting student work and thinking. These are difficult behavioral changes for many teachers to make.

School-Level Organizational Factors

In comparison to introducing new subject matter and inactive materials, most of the factors explaining the incorporation of changes in classroom interaction patterns are at the local level. In his well known work, Sarason finds that the behavioral regularity of the traditional mode of teaching is difficult to change because of the pressures on teachers to cover certain subject matter; the routines of school life that reinforce this regularity, and the lack of "consultant help" from principals, curriculum supervisors, workshops, and so forth, for making the required change.* The expectations of parents regarding what is the proper form of schooling could also be added, as well as peer pressures from other teachers. These factors can be grouped into two categories: the lack of direct assistance to teachers from supervisory personnel and the organizational environment in schools favoring maintenance of traditional teacher behaviors. The powerful influence of these factors on teachers is amply shown by Sarason.

Implementation Support from Publishers

Another source of direct assistance to teachers would be publishers, if they had more capacity to provide implementation support for the curricula that they produce. The assistance that publishers have traditionally provided has been mostly limited to one or teo day workshops for teachers to familiarize them with the basic objectives and features of new materials. Some companies are beginning to provide longer workshops and some follow-up support, but not to a great extent. (Some small firms may be providing a higher level of service.) In the terminology introduced in Chapter II, this lack of implementation support means that publishers do not have much capability for integrating the curriculum resources that they produce in the schools, or that as a resource providing institution publishers have not reached the "integration state."

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*Seymour B. Sarason, *The Culture of the School and the Problem of Change*, Allyn and Bacon, 1971, pp. 72-78.

We will consider lack of publishing integrative capacity in implementation to be a factor limiting the incorporation in the school curriculum of innovations requiring significant change in teacher behavior on the assumption that with increased capability there would be greater incentive for investment in programs involving such innovations. The rationale is that with greater capability for providing implementation support teachers would be more likely to adopt curricula requiring behavioral change and to successfully incorporate the required behaviors, making them more likely to be steady customers.

However, the validity of this assumption needs to be assessed since it is not clear how effective implementation assistance from outside school districts can be in supporting incorporation of curriculum innovations at the school level. We will deal with this issue in the next section, where we will summarize existing evidence on the effectiveness of NSF's implementation programs.

Major expansion of publishers' capability to provide teachers with implementation support would involve significant institutional change within the industry and in their relationship with local school districts. Publishers' concept of their product would have to shift from providing materials to providing materials and integrative services and they would have to develop effective strategies and nationwide capability for providing these services. Providing these integrative services would entail a far different relationship with school districts and teachers than publishers have traditionally had in supplying only textbooks which are largely self-implementing. Finally, a restructuring of the traditional ways in which school districts provide inservice support to teachers through workshops conducted by internal staff and subsidization of coursework in universities would have to occur in order for publishers to have markets large enough to make it worthwhile for them to sustain their services.

Summary

In summary, the major institutional factors affecting the macro-implementation of changes in classroom interaction patterns are the organizational norms in schools favoring maintenance of traditional teaching behaviors and the lack of direct implementation support for teachers to make the necessary changes. These factors are diagrammed in Fig. __.

Other institutional factors limiting the incorporation of changes in classroom interaction patterns could also be considered. As we briefly discussed in Chapter II, in the section on influences of schools of education on the school curriculum, two possible additional factors are the socialization of teachers to the way that they were taught by their professors in schools of education (and earlier by their teachers in elementary and secondary schools), and the lack of specific training in schools of education in more open teaching methods. Standardized tests could also be a factor to the extent that they add to pressures on teachers to cover certain subject matter and do not emphasize higher order cognitive skills.

FEDERAL SUPPORT OF SCHOOL-LEVEL IMPLEMENTATION ACTIVITIES

In assessing existing evidence on the effectiveness of outside support for school level implementation of curriculum innovations, there are two main issues. First, there is the general issue of the kinds of change caused by direct support of school level implementation activities. Three different kinds of change can be distinguished:

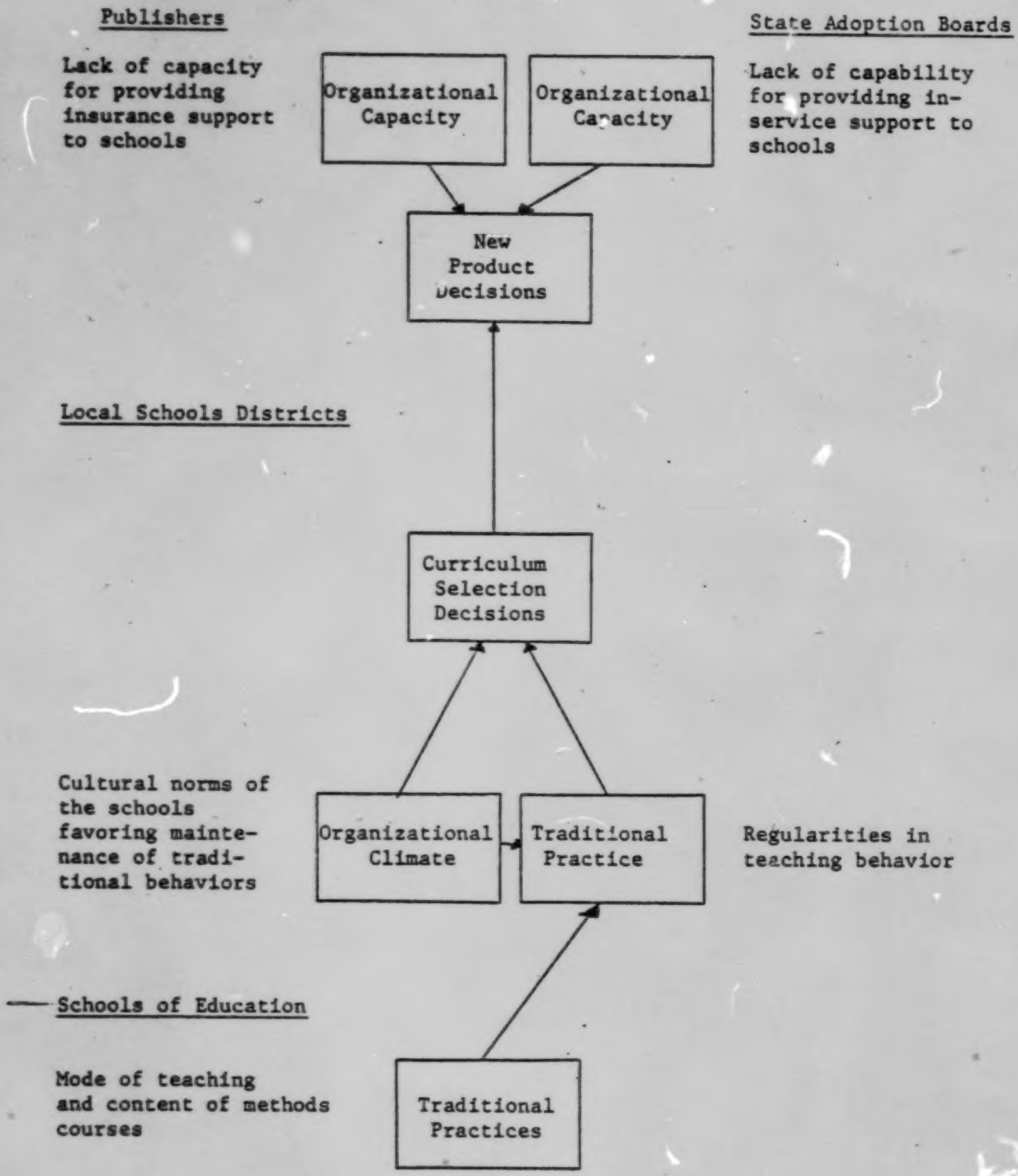
Publishers
Lack of capacity for providing insurance support to schools
Organizational Capacity
Organizational Capacity
State Adoption Boards
Lack of capability for providing in-service support to schools
New Product Decisions
Local Schools Districts
Curriculum Selection Decisions
Cultural norms of the schools favoring maintenance of traditional behaviors
Organizational Climate
Traditional Practice
Regularities in teaching behavior
Schools of Education
Mode of teaching and content of methods courses
Traditional Practices

Fig. __--Organizational Factors Affecting the implementation of changes in classroom interaction patterns

(1) more adoptions of specific curricula in schools than would normally occur, (2) more complete incorporation by teachers of the innovations in curricula adopted; and (3) the indirect effect of more change in the institutional factors limiting incorporation because of the higher level of usage of the specific curricula in the schools. In this section, we will deal only with the first two of these kinds of change. Discussion of the third kind is postponed to later chapters. Second, there is the subordinate issue of whether some strategies of providing direct implementation support are more effective in producing each of these kinds of change than others.

Although the existing evidence relevant to these issues is limited in both quality and extent, their importance to federal policy in supporting national curriculum development requires summarizing what is available. In Chapter II, we identified the policy alternative of terminating federal support at the completion of development and leaving incorporation to existing processes in the curriculum policymaking system. If direct implementation support does not produce more incorporation in the school curriculum than would normally occur, then federal policy should be either shifted to other forms of implementation if these are found to be effective, or if not, to either terminate funding at the completion of development or not support national curriculum development at all, if development alone is found not to produce much change.

Our analysis will employ mainly the available evidence on the effectiveness of NSF's implementation activities, even though much of the more general literature on educational innovation is relevant. The evidence on NSF activities is the most germaine to the innovations that we are considering in this report and is sufficient for addressing some of these issues. References to the more general literature on educational innovation will be included as needed.

NSF's School Level Implementation Strategies

NSF's school level implementation activities can be divided into five different strategies. As has been previously discussed, two major differences in strategy are projects to upgrade teacher's subject matter competency--which we will call subject matter oriented projects*--and projects supporting the plementation of specific curricula. As shown in Table __, NSF has historically funded the subject matter oriented projects as a much higher level than the projects to support the implementation of specific curricula. Within the category of projects to implement specific curricula, there are four sub-categories that NSF calls Awareness projects, Teacher-centered projects, Resource Personnel projects, and School System projects.

Awareness projects are simply for the dissemination of information about new science curricula with a strong emphasis on NSF developed materials. These projects are typically conducted by a university faculty member and attended mostly by curriculum supervisors and school administrators. The intent is to encourage the adoption of these new science programs and to provide information on sources of support for teacher training.

Teacher-centered projects provide training in the implementation of one, or sometimes several, NSF developed curricula. These projects are also typically conducted at a university by a faculty member and

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*Nearly all of these projects were for high sch

Table

DEVELOPMENT COSTS OF SELECTED NSF NATIONAL CURRICULUM PROJECTS (millions)

Project Name	Grade Levels	Total Development Cost	Cost per Grade Level
Mathematics			
School Mathematics Study Group	K-12	$14.4	$1.1
University of Illinois Committee on School Mathematics	9-12	4.9	1.2
Minnesota School Math and Science Project	K-3	5.0	1.2
Science			
Physical Science Study Committee	12	5.3	5.3
Biological Sciences Curriculum Study	10	10.4	3.5
CHEM Study	11	2.6	2.6
Technology and the Man-made World	11	2.0	2.0
Time, Space, and Matter	7-9	1.2	.6
Earth Sciences Curriculum Project	7-10	3.5	3.5
Introductory Physical Science	7-9	.8	.8
Physical Science II	9-10	.6	.6
Human Sciences	7-9	1.2*	--
Science Curriculum Improvement Study	K-6	4.3	.6
Elementary Science Study	K-8	7.6	.8
Science - A Process Approach	K-6	2.3	.3
Unified Science and Mathematics for the Elementary School	K-6	2.6*	--

SOURCES: U.S. House of Representatives, "The National Science Foundation Curriculum Development and Implementation for Precollege Science Education," Committee on Science and Technology, 94th Congress, 2nd Session, November 1975, pp. 303-308, and internal NSF report.

NOTE: *Development is not completed for Human Sciences and Unified Science and Mathematics for the Elementary School. Final development costs will be greater than shown.

are attended by individual teachers, usually from a number of different school districts. Two types of these projects are workshops that teachers attended for a few weeks during the summer and workshops that teachers periodically attend throughout the school year. Since many of the teachers have not previously made an adoption decision, the intent of these workshops is both to encourage adoption and provide sufficient training for successful use.

Resource Personnel projects are for training school personnel in specific curricula to a level where they are able to initiate and carry out training efforts in local school districts. These projects are also typically conducted in universities but are limited to personnel who are in a position to assume responsibility for curriculum implementation in local school districts. These personnel may include college faculty, school administrative personnel, curriculum supervisors, principals, and resource teachers.

School System projects involve a prior commitment by one or more school districts to work with a group of university faculty for the purpose of implementing curriculum improvements. Funds can be used for adapting materials to local needs, inservice training for teachers, and purchasing needed materials, equipment, and supplies.

For the purposes of this study, the critical differences in strategy among these types of NSF projects are that the awareness projects are only for dissemination of information, the teacher-centered are only for training individual teachers with no requirement for commitment to implement change from their school districts, resource personnel projects are mainly for training leadership personnel, to initiate implementation activities in local school districts, and the school system projects involve a commitment by school district administrators to a comprehensive planned change effort.

Funding for these different types of projects has been provided both directly through several different implementation programs as well as indirectly through individual curriculum development projects. In most of these programs, more than one type of project has been funded so that the funding by program is not in one-to-one correspondence with the data categories shown in Table __. In the case of funding channeled through development projects, training activities are typically conducted by the developers as an integral part of the development effort and may not be strictly identifiable as a spearate project. The data in Table __ include both of these forms of funding. NSF's implementation programs have included Academic Year Institutes, Summer Institutes, Inservice Institutes, Resource Personnel Workshops, Cooperative College School Science Programs. Individual programs have been discontinued and relabeled overtime.

Effect on Adoptions

The evidence that we found on the effects of implementation activities on adoptions is for the resource personnel and teacher-centered types of support.

Resource Personnel. The most useful data on resource personnel training that we found are from the Science Curriculum Improvement Study (SCIS) which is one of the three major NSF elementary science curriculum projects. These data concern almost 800 resource personnel that were trained by SCIS. Analysis of these data indicates that these personnel may have had a strong effect on initial adoptions of the SCIS curriculum.

The analysis is a correlation of the goegraphic location of adoptions of the SCIS curriculum in the first five years after its initial commercial availability with the geographic location of the resource personnel trained by SCIS. The results of this analysis, which are shown in Table __, are that initial adoptions of the SCIS materials are highly correlated with the geographic location of the resource personnel trained by SCIS. This indicates that without the resource personnel training activity, SCIS adoptions might have been an order of magnitude lower than they are, since the average level of adoptions is lower by this amount in the states where few resource personnel were located. Since approximately 8 percent of teachers across the country were using SCIS in 1976,* the implication is that without the resource personnel training activity in the project fewer than one percent of teachers across the country might have adopted SCIS.

From insepction of some of the raw data from which Fig. __ was determined, it is likely that the correlations of adoptions with resource personnel would be significantly greater if we had chosen school districts or some other geographic unit smaller than a state as the unit of analysis, since many adoptions tend to cluster in very small regions of a state. We did not do this because we were limited to hand computation. In presenting the data by state, the correlation of adoptions with resource personnel is significantly diluted.

The data points in Fig. __ having arrows pointing to the right indicate states in which support was provided for SCIS resource centers. These were instituted at various times in the 1970-1974 time period, with either project funds or by the publisher from royalty payments.

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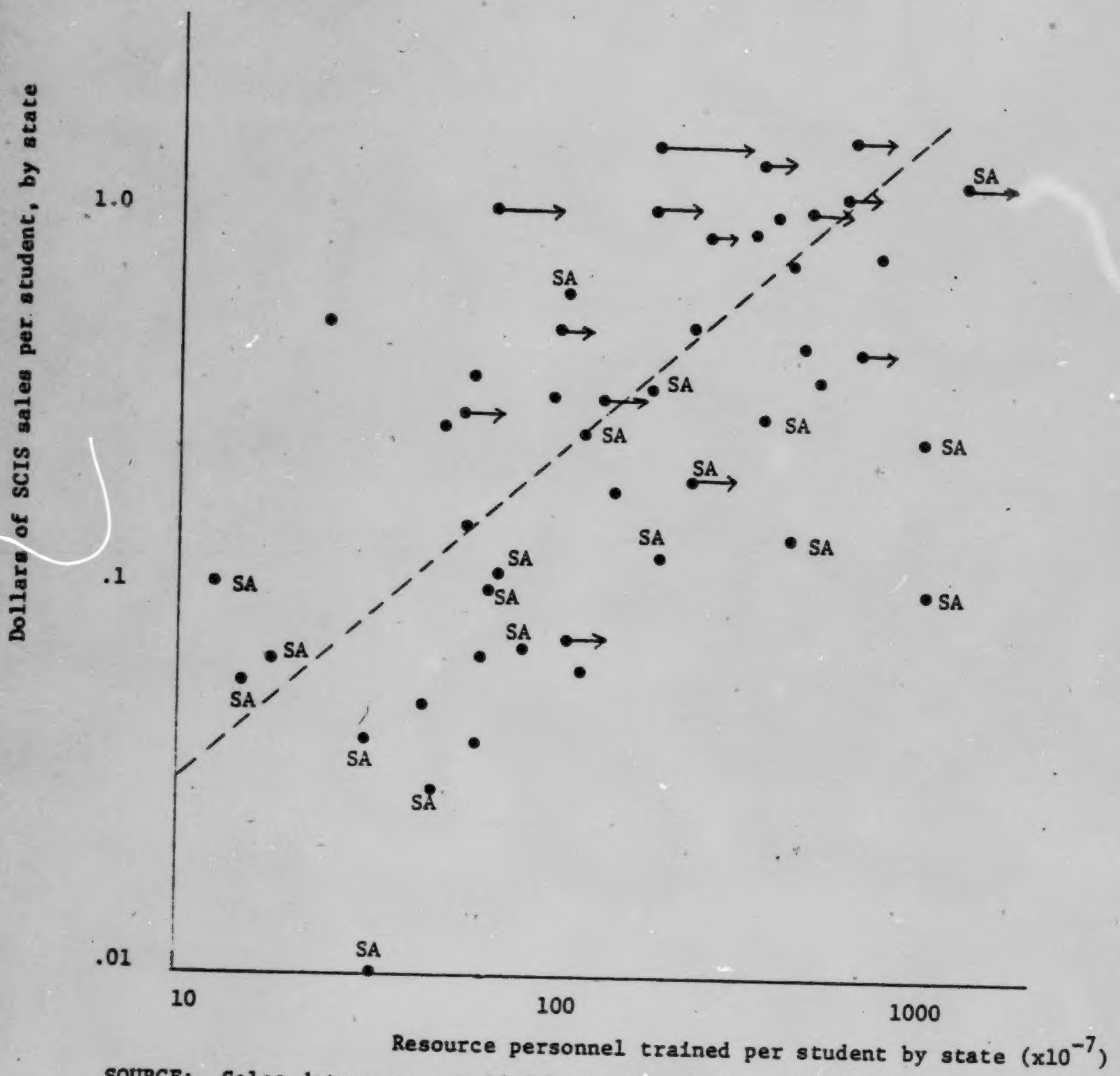
*P. Kenneth Komoski, op cit.



SOURCE: Sales data were provided by Rand McNally, the SCIS publisher. Resource personnel data were from lists of trainees provided by SCIS.

NOTES: States with the long arrows had two or more resource centers. Rhode Island and New Hampshire had no resource personnel. These states are close to Massachusetts which had three resource centers.

Fig. --Correlation of resource personnel trained to adoptions of the SCIS curriculum (1970-1974)

As one of their functions, these centers also provided training for resource personnel, so the numbers of these personnel trained, should be added to numbers of personnel trained at SCIS. This would shift the positions of the states in which these centers are located to the right, but the necessary data are not available to do this.

We have also indicated in Fig. __ which states ahve adoption boards and the results clearly are that these states tend to have fewer adoptions even when the same number of resource personnel have been trained. It is not possible to determine from these data whether subject matter priorities or adoption procedures are the causative factor. However, these data generally support our conclusions earlier in this chapter that the adoption boards have a limiting effect on incorporation.

Although the results in Fig. __ are consistent with the conclusion that the resource personnel trained by SCIS significantly increased the level of adoptions, causality has not been shown. Another explanation of the geographic clustering phenomenon is that adoptions spread through a highly local process in which local use served as a demonstration of curriculum effectiveness, which generated interest among colleagues of the initial users in supporting additional adoptions, who then initiated implementation activities in their nearby area and so forth in a continuing growth process. Incidently, many of these people applied to SCIS for resource personnel training. With this model of the adoption process, the SCIS resource personnel training had no effect on the level of the adoptions.

The true explanation is probably that the SCIS resource personnel activity reinforced the local growth process through increasing the participants knowledge of the SCIS curriculum skills in supporting implementation, and commitment to implementation. SCIS followed what was called an internalization strategy in training resource personnel, which has five key features. First, SCIS only accepted participants whose home institutions expressed a commitment to support implementation of some science curriculum improvement. As an indicator of this commitment, SCIS only paid participants travel expenses and required that travel expenses be paid by their home institutions. Second, the one week training sessions were planned in response to needs expressed by the participants after they had arrived and had some time to meet with SCIS staff and try out the materials for themselves. The purpose was to make SCIS concrete and adapt the training experience to each participant's needs. Third, much of the one week period was spent visiting with staff members, participating in staff discussions on development problems, and visiting classrooms where SCIS was being used and talking with the teachers. In a low key manner, the idea was to communicate the spirit of SCIS to the trainees and make them feel personally involved in a peer relationship with the developers in order to increase commitment to adoption. Fourth, time was spent not only on the theory and practice of SCIS but strategy for implementing it (or some other science program) in schools. Similarly, to the way that the trainees were being exposed to SCIS, the strategy generally involves finding a few volunteer teachers and administrators willing to make a commitment to implementation, initiating pilot implementation in the classrooms of the volunteer teachers, followed by efforts to secure top level administrative support and funding for expanding implementation and building a network of teachers committed to SCIS. Fifth, the SCIS director maintained contact with the trainees after they returned to their home institutions through newsletters and personal contacts, and put them in touch with the local salesmen of the SCIS publisher. Over time, a loose network of people interested in SCIS had been created.

Teacher-centered. For teacher-centered training activities we found three sources of data. As for the resource personnel trained by SCIS, these studies show strong correlations between participation in a training program and adoption of a new science curriculum.

One of these studies is an analysis of adoptions by a sample of about 225 elementary teachers who attended a training program centered at a university. These teachers were compared to about 250 other teachers in the same region who had not attended the program. As shown in Table __, the findings are that sixty-six percent of the teachers attending the training program have adopted one or more of the NSF elementary science curricula as opposed to 25 percent of the teachers who had not attended. Levels of use varied among these teachers from supplementary to exclusive use of the new science curricula. No attempt was made in the study to determine whether any of the teachers not attending the training program had attended some other NSF training program, so the figure of 25 percent may actually be lower for teachers who did not receive any outside funded implementation support.

Another study containing relevant data is the national survey of elementary science teaching referenced earlier in this report. One finding in this study was that among the 85 different variables considered, 77 percent of the variance as whether or not a teacher was using an elementary science curriculum was explained by whether the teacher had attended a workshop or institute for curriculum specific training

Table

PERCENTAGE OF TEACHERS ADOPTING A NEW ELEMENTARY SCIENCE CURRICULUM 1970-1973

NSF Curriculum Adopted	Attended the Training Program*	Did Not Attend the Training Program
SCIS	44	7
ESS	40	11
SAPA	8	6
One or More	66	25

SOURCE: Victor L. Willson, "Five Year Usage Patterns for NSF Sponsored Curricula," School of Education, University of Minnesota, Minneaoplis, Minnesota, December 1975, Tables 2 and 3.

NOTE:

*The training program was the Portal School Project centered at the University of Wyoming.

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Another study containing relevant data is the national survey of elementary science teaching referenced earlier in this report. One finding in this study was that among the 85 different variables considered, 77 percent of the variance in whether or not a teacher was using an elementary science curriculum was explained by whether the teacher had attended a workshop or institute for curriculum specific training.

As with the data on SCIS resource personnel, these correlations are not sufficient to draw any firm conclusions about causality. Many of the participating teachers may have already decided to adopt a new science curriculum and then sought a workshop or institute where they could receive some training. But since previous adoption is rarely a condition for participating in an NSF training project, the likelihood is low that these high correlations are entirely due to previous decisions to adopt.

Some data indicate that training activity has a substantial effect on decisions to adopt are shown in Table ___. These data were obtained from a survey in the school year 1972-1973 of 1600 intermediate and high school teachers and some curriculum supervisors who attended teacher training projects sponsored by NSF in the summer of 1970. By 1971-1972, 45 percent of these teachers had adopted the curriculum empahsized in the institutes that they attended as their primary program, and another 24 percent had adopted parts of the curriculum emphasized, for a total of 69 percent. In comparison, only 33 percent were already or knew that they would be teaching the curriculum at the time that they had attended the training institute one year earlier. Thiry five percent indicated that their primary reason for attending the institute was gaining information that would assist them in making an adoption decision. Another 13

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Table

PARTICIPANTS' REASONS FOR ATTENDING NSF TEACHER-CENTERED TRAINING PROJECTS

	Number of Teachers	Percent
Reason for project attendance in 1970		
Already teaching the curriculum	349	22
Will be teaching the curriculum	183	11
Assistance in decising on adoption	559	35
Obtain background to lead implementation	206	13
Other	310	19
TOTAL	1607	100
Extent of use in 1971-1972		
Used as primary program	731	45
Used as supplementary program	389	24
Plans to use in the future	27	2
No plans to use	210	13
Other	250	16
TOTAL	1607	100

SOURCE: Thomas Gibney, "Evaluation of 1970 Summer Institutes Program for Secondary School Teachers of Sciences and Mathematics Programs," Center for Educational Research, Toledo University, Toledo, Ohio TM 002 379, Table 5.01.

83

percent attended to obtain the "background" that would be of assistance in leading implementation in their schools. Whether the teachers in this category were strongly committed to making an implementation effort or not is unclear because of the way that the question was phrased in the questionnaire used. Some may have become more committed to an implementation effort as a result of their training experience. At any rate, at least one-third of the participants attended expressly to gain information for making an adoption decision and the influence of the training program on teachers was apparently great enough that adoptions doubled.

Trial Centers. Another mode of teacher-centered training has been through the

trial centers supported by the development projects to obtain feedback on the success of materials produced for the purposes of revising them. In early projects, these centers typically consisted of a number of teachers in different schools within a small geographic area who were provided with a small budget for equipment and travel expenses so that they could periodically meet together and discuss their problems in using the trial materials provided by the project and prepare reports for the developers. Most of the projects also provided consultants who made periodic visits to assist the teachers, but mainly the new curricula were implemented in these trial sites through peer teaching. In effect, these teachers trained themselves. As development proceeded, most of the early projects increased the number of centers

until by the end, some projects had more than 100.* As an economy measure, NSF subsequently reduced the number of centers that could be supported, which forced the development projects to shift to using a few schools as trial centers.

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The early science projects found that their trial centers were important to initial implementation in that early adoptions were mostly in the neighborhood of the trial schools. For example, in PSSC project over a quarter of the participants in the eraly institutes for physics teachers were from the "immediate neighborhood" of the trial schools and a third of the PSSC users.* Thus, the trial centers not only provided feedback information to the developers, but also supported local adoptions through functioning as demonstration sites where colleagues of the trial teachers could come and see the new program in action. These teachers could then apply for training at an NSF institute. For these purposes, the number of trail centers was much larger than strictly needed for development purposes in the early science projects.

Summary. The model that emerges from these data is that there are three critical factors in explaining initial adoptions of the new science curricula: (1) local networks of school personnel (and probably including faculty in nearby universities), (2) schools where the curriculum can be observed to be in use, and (3) federal implementation support. Federal implementation support apparently produces at least a third of initial adoptions and works through increasing the commitment to adopt and either directly or indirectly through providing resource personnel. The functions of these resource personnwl range from actively initiating local implementation efforts to serving as a source of confirmation for teachers in the local area interested in using a new curriculum. The evidence that we presented concerning the secondary school level teacher centered projects indicates that the effect on subsequent adoptions may be equally strong, since most of the curricula included had been on the market for more than five years at the time that the data were collected.

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*Paul E. Marsh, "Wellsprings of Strategy: Considerations Affecting Innovations by the PSSC," in Matthew Miles, ed., op cit., pp. 263-264.

The actual effect of federal implementation activities may be subsequently higher but this is impossible to determine because there are no data for comparing adoption levels with and without federal support. If no federal support for implementation had been available, it is possible that many of the teachers who reported in the studies that we reviewed that they had decided to adopt prior to attending a training project would have decided not to adopt if the training had not been available. As shown in Table __, slightly more than 50 percent of high school science teachers have attended a NSF training project, which is about the maximum usage level that the early high school science curricula reached (data will be shown for BSCS in Chapter VI). Funding for elementary level implementations activities has been substantially less (only a few of the subject matter oriented NSF implementation projects and about half of the curriculum specific projects have been for the elementary level), and so have adoptions. About 15 percent of elementary teachers were using an NSF science curriculum in 1976[*] which is about the same level as the number of teachers who report that they have received specific training (14 percent in the sample survey).[**] NSF implamentation funds were temporarily terminated in FY__ and FY__ and all the publishers of recent NSF curricula whom we interviewed reported that sales have markedly decreased in this period, but this decline may also be attributable to the "back-to-basics" movement or budget pressures in local school districts. Finally, publishers typically ask the developers of national curricula in bidding for publishing rights about the extent of trial center work and efforts to build personnel networks. In industry parlance, this is known as the "built-in market" for a curriculum.

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[*] Kenneth Komoski, op cit.

[**] George Steiner, op cit.

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Table

PARTICIPATION OF HIGH SCHOOL TEACHERS IN NSF FUNDED TRAINING PROJECTS

Number of Training Projects Attended	Biology teachers	Chemistry teachers	Physics teachers	General Science teachers
Funded by NSF*				
One	(33)	(37)	(39)	(29)
Two	(16)	(20)	(21)	(13)
Three or more	(1)	(2)	(3)	(1)
SUBTOTAL	50	59	63	45
Funded by other federal, state or local agency	9	8	5	10
No training project attended or no response	41	43	32	44
TOTAL	100	100	100	100

SOURCE: Martin Herskhowitz, op cit., Tables A1, A2, A3, and A4.

In summary, existing data are consistent with a conclusion that without federal implementation support either indirectly through development projects or directly through training programs, adoptions of nationally developed curricula would not reach significant levels. There is probably a difference in the importance of implementation support depending on the degree of innovativeness of a new curricula in relation to institutional factors but even for relatively simple changes, as in the early high school science projects, implementation support appears to be critical. The implication is that policies of supporting development without implementation would not likely result in significant adoptions in the schools of the curricula developed and therefore little incentive for incorporation of the innovations in these curricula in other institutions in the curriculum policy-making system.

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Effects on Incorporation

Assessment of the effects of federal implementation activities on the incorporation of curriculum innovations is far more difficult because there is so little data.

Research on Teacher Behavior. One potential source of evidence is many studies in the research literature of the effects on teacher behavior of participation in a curriculum-specific training project funded by NSF. Although these studies generally find some effects consistent with the objectives of the curriculum involved, the experimental designs are inadequate for the purposes of this study. The major problem is that the experimental designs do not enable separation of the effects of the training from effects of the materials used. Furthermore, very few of these studies measure the persistance of teacher behavior over time. Our impression from reading some reviews of the research on teacher behavior is that the effects on teacher behavior are substantially greater for curricula based on enactive materials, such as the elementary science programs, than on textbooks such as the early high school science programs.* Some of the studies on the textbook programs show no significant difference while most of the studies on curricula based on enactive materials show significant differences.

In the survey of elementary science practices references above, bivariate correlations of all 85 variables used in the study were compiled and the findings were that: (1) teacher use of lecture-discussion as a frequent learning activity was negatively correlated with use of a new science curriculum and with participation in a training project on the new science curricula, but positively correlated with use of a single textbook, (2) that teacher use of individual laboratory as a frequent learning activity

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*A.L. Balzer, "A Review of Research on Teacher Behavior," ERIC Science, Mathematics and Environmental Education Clearinghouse, Ohio State University, Columbus, Ohio, 1973.

was positively correlated with use of a new science curriculum and participation in a training project but negatively correlated with use of a single textbook, (3) that teacher use of group laboratory was also positively correlated with the two new science curriculum variables but negatively correlated with use of a single textbook, and (4) that teacher use of small group discussion, independent study, and field excursions was not correlated with any of these variables.* These results indicate that training plus use of new science curriculum materials is positively associated with a more open, laboratory oriented classroom environment. However, there was no pretesting of teacher behavioral variables nor did the design enable separation of the use of materials from training. (As reported earlier, teacher use of the new science materials was highly correlated with participation in a training activity, since 77 percent of the variance in use of the new science materials was explained by participation in a training activity.)
The fact that in every case usage of the new science curriculum materials was more strongly correlated with these classroom interaction variables than participation in a training activity suggests that the training does not contribute substantially to changing teacher behavior beyond use of the materials alone.

Overall, existing studies of teacher behavioral change are not sufficient to reach any conclusions for the purposes of this study.

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*The text of significance was a correlation significantly different than zero at a confidence level of .001 using the "F" test in four of eight regions of the country that were defined.

Configuration in Use. Also, we did not find any studies of the effects of training on the configuration of use[*] either during initial adoption or thereafter, even at the simplest level of the extent to which curricula adopted are the main course of study or are used in a supplementary way. The few existing studies of use configurations tend to show substantial adaptation in the use of materials and in teacher incorporation of different innovations in these materials, but not in relationship to implementation strategy.[**]

Length of Usage. Another measure of incorporation is the length of time that a teacher continues to use a new curriculum after first adoption. This is an imperfect measure in many ways, since mere use does not indicate the extent of actual change in the classroom nor that the teacher may have switched to another curriculum requiring similar behaviors. Nevertheless, a high rate of rejection after initial adoption of a specific curriculum would be an indicator of a lack of incorporation.

The only results that we found on the length of usage are from the study of the teacher-centered training project based at a university, which was referenced in the previous sub-section. The results are that usage apparently falls to over-time to about 50 percent of initial adoptions, with no substantial differences between teachers participating in the training project and those not participating. As shown in Fig. __ the rate of decline was lower for the early adopters than the later adopters, as might be expected.

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[*] Configuration of use will be defined in Chapter II.

[**] The two most thorough studies are James Gallagher, op cit., and

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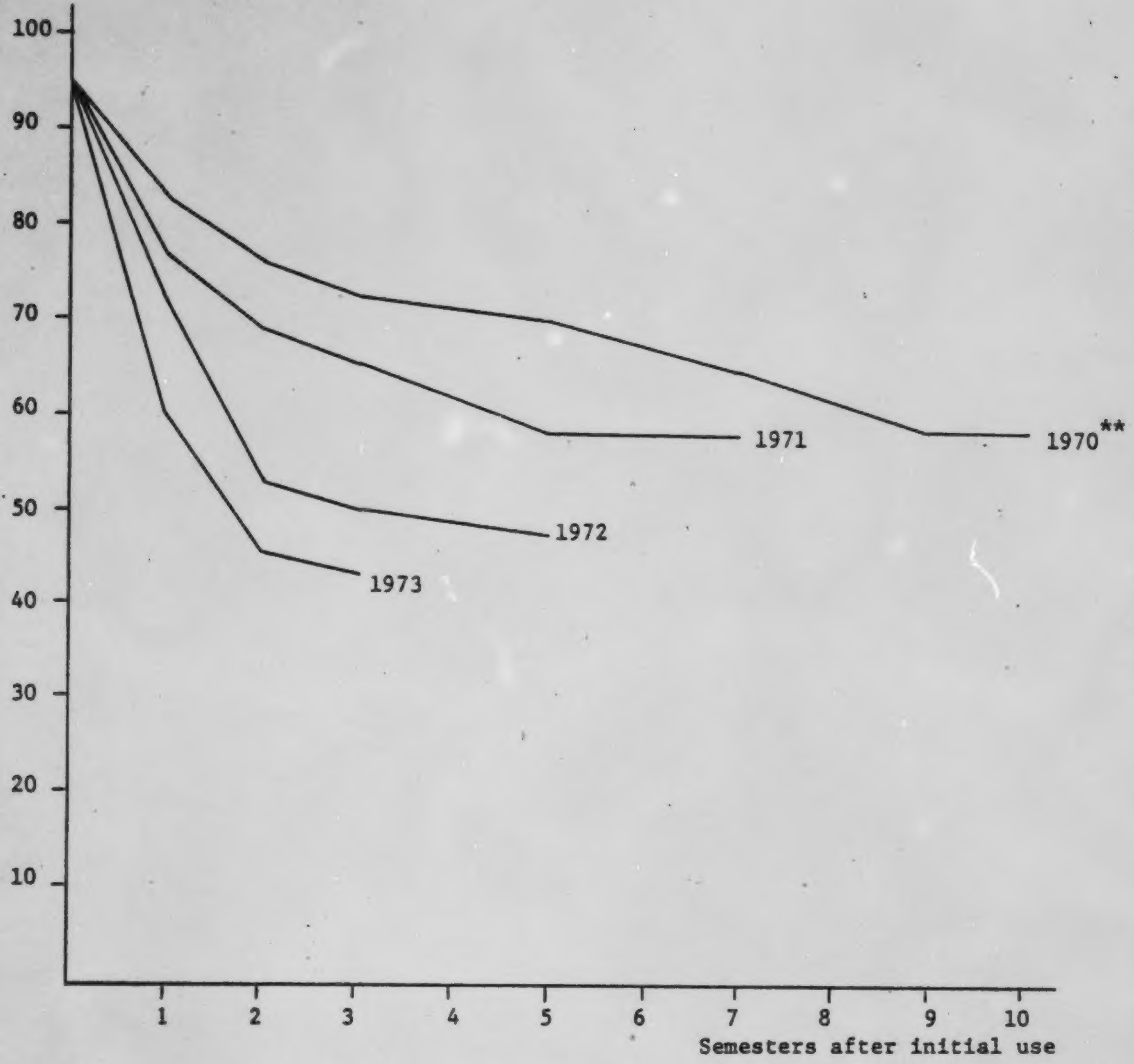


SOURCE: Victor Willson, op cit., p. 24.
NOTES:

*Differences between teachers participating in the training project on which these data are based were not significantly different than for a control group. Data for both the trained group and control group are combined. The curricula included were SAPA, ESS, and SCIS.

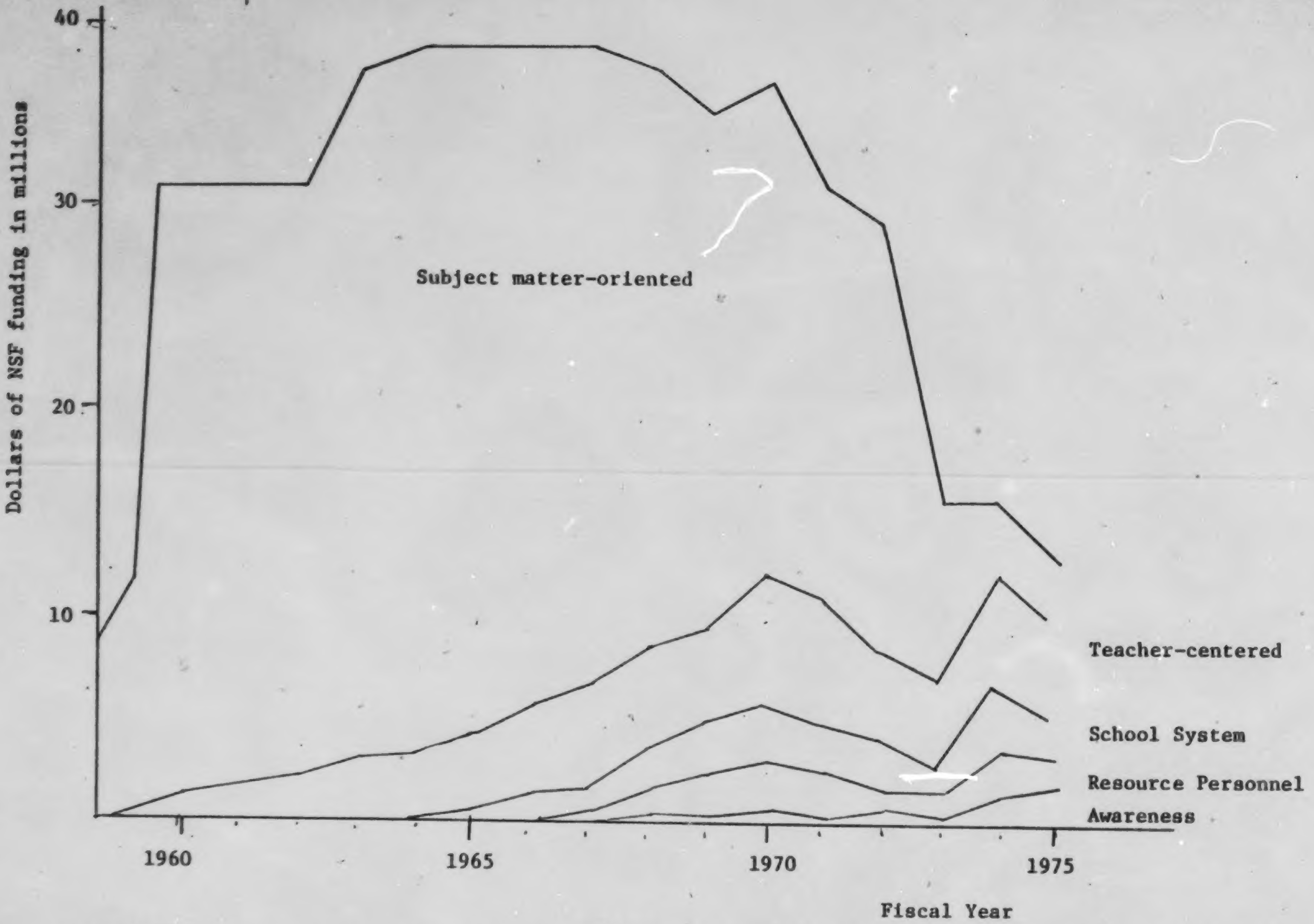
**Year of Initial Use.

Fig. —Length of teacher usage of NSF elementary science curricula after initial adoption*

Alternative Implementation Strategies. Although the quality and quantity of existing research is totally inadequate to draw any conclusions, the trend of the evidence is that the training activities supported by NSF have not made a substantial difference in teacher incorporation of curriculum innovations from the national curriculum projects. Whether this implies that direct implementation support cannot be effective or that the wrong strategies have been followed is unclear.

Strategies that may be more effective than others are represented among the projects in NSF's implementation program. As indicated in Fig. ___, the large majority of NSF's implementation projects have followed the summer workshop model where teachers go to a university for a few weeks of training, and then return to their classrooms and may attempt implementation. Some of these workshops are sequential in that teachers may return periodically for further training but the assumption is that implementation does not require direct support for teachers in their organizational environment.

An example of a different strategy has been followed by a SCIS resource center located at a university. A phased approach is followed to achieve successively increased levels of use over a period of time. First, the director approaches influential administrators in a school district to gain their support for an implementation program. This may require a year of meetings, showing the curriculum in use in classrooms to the administrators, providing information, doing small tasks for them, and so forth. When the administration is willing to make a commitment to implementation, including provision of their own funds, volunteer teachers are found



SOURCES: U.S. House of Representatives, "The National Science Foundation and Precollege Science Education: 1950-1975," Subcommittee on Science, Research, and Technology of the Committee on Science and Technology, 94th Congress, 2nd Session, January 1976, Appendix A, and internal NSF report.

Fig. --NSF funding of inservice training projects who will pilot the curriculum in their schools for up to a year. If the administrators like what they see and are willing to support further implementation, the director conducts inservice training sessions for large numbers of teachers within the district using NSF implementation project funds. Schools where there are only a few interested teachers are discouraged from sending any teachers until a later date so that there is a "critical mass" of teachers in each school. The purpose of this inservice training is partly to convince the teachers that the curriculum is worthwhile for them to adopt but mainly to identify candidates for resource teachers positions in each school or nearby schools. These candidate resource teachers are then given further training in the SCIS curriculum, as well as implementation techniques. The director arranges beforehand with the administrator for release time for the teachers selected and to obtain project grants from state funds or other sources as necessary. These resource teachers then provide day-to-day assistance to teachers who decide to adopt the curriculum. Thus, teachers learn the curriculum as they are teaching it. The resource teachers are also expected to conduct periodic teacher meetings to work out problems and adapt the curriculum to their needs. In addition, the director has over time selected a few of the more effective resource teachers to become consultants who travel around to all of the districts that the center is working with to assist with problems. Finally, the center supports afterhours workshops for teachers who want to develop their own science materials, learn some science, talk about problems, hear a lecture and so forth. In effect, the resource center is also a teacher's center for any teachers who want to participate. The key elements of this strategy are: obtaining top-level support for initial implementation, conducting pilot demonstrations to generate interest, providing teachers with implementation support in their classrooms, peer-teaching through meetings and having a large number of teachers in each school, supporting adaptation, and building a network among the participating teachers to encourage higher levels of use. The director reported to us that extensive implementation activities were underway in over 20 school districts. This is a good example of the curriculum-based implementation strategy that we discussed in Chapter II.

Higher levels of use in schools might result if this implementation strategy was modified to include other curriculum alternatives to SCIS. This would increase the likelihood of schools combining several programs to meet their needs and in the long run greater capacity for local development. This suggests a federal implementation strategy of supporting more broadly based resource centers capable of helping schools with the implementation of curriculum or another but also higher level of use in a sequence of stages.

Summary

In summary, existing research evidence indicates that incorporation of innovations from the national curriculum projects in the school curriculum would have been substantially lower without federal support of implementation activities, but mainly through stimulating additional adoptions rather than more complete implementation. The increase in adoptions is apparently about a third and may be substantially higher. Adoptions increase incorporation to the extent that materials structure teacher behavior and subject matter choices, and that usage persists. Federal implementation funds apparently affect adoptions through accelerating a highly localized process dependent on collegial relationships and demonstrations of successful use. Implementation strategies intended to increase local administrative support, provide on-site resource personnel, reinforce peer relationships, and encourage higher levels of use might increase the extent of implementation.

NEW PRODUCT DEVELOPMENT IN PUBLISHING

We have already discussed in this chapter how lack of integrative capacity in publishing to implement highly innovative curricula tends to favor maintenance of the existing school curriculum. As outlined in Chapter II, one further consideration is institutional factors limiting publishers' capacity to invest in the development of highly innovative curricula. From our interviews with publishers, there are three important factors: funds available for investment in new products, strong incentives to develop programs acceptable to the majority of teachers, and the rapid rate of change in other dimensions of the school curriculum than we have been considering, which requires that new products be developed in a short lead time.

Levels of Investment

Being dependent on sales to states and local school districts, the funds that publishers have available for investing in new product development are largely determined by revenues earned and the industry cost structure. A breakdown of this cost structure and the revenues earned by differently sized firms is shown in Table ___. As this table shows, publishers typically invest 10 percent of their total revenues in new products after they have paid about 35 percent of these revenues for product manufacturing (including the costs of making plates and printing and binding), 8 percent for distribution, 20 percent

COST STRUCTURE OF EL-HI PUBLISHING FIRMS,
(dollars in millions)

	Average Smaller Firm		Average Medium-sized Firm	
Size range (net sales)	Up to $8 million		Between $8 and $25 million	
Number of firms	11		11	
	Dollars	Percent of sales	Dollars	Percent of sales
Revenues	3.6	100	15.3	100
From sales (net)	(3.5)	(97)	(15.0)	(98)
From other sources	(.1)	(3)	(.3)	(2)
Costs				
Product development	.39	12	1.65	11
Royalties	(.21)	(7)	(.89)	(6)
Editorial	(.13)	(4)	(.55)	(4)
Production	(.05)	(1)	(21)	(1)
Manufacturing	1.24	35	5.96	49
Plant costs	(.14)	(4)	(1.00)	(7)
Paper, printing, etc.	(1.10)	(31)	(4.96)	(33)
Distribution	.27	8	1.56	8
Marketing	.87	25	3.66	24
Administration	.48	13	1.91	13
Net income				
After taxes (profit)				
Before taxes	.21	6	.67	5
Taxes	.08	2	.42	3
Profit	.13	4	.25	2

SOURCE: "Industry Statistics, 1975," Association of American Publishers, New York, 1976, T
longing to the AAP.

for marketing and sales, 12 percent for overhead, and 6 percent to stockholders, as profits. For the average large firm, this amounts to about $5.3 million per year, and for smaller firms, only about $400,000 for new products. In the average firm, about 60 percent of these funds are spent on royalty payments to authors, 30 percent for editorial staff and consultants, and 10 percent for what is called production (layout, photography, artwork, and copyediting). Investment in new products for the whole industry across all subject areas is about $50 million.[*]

There are only two ways that the industry could afford to increase this level of investment. First, cost reduction in certain categories might release resources for use in product improvement. But it is hard to see where these cost reductions could be made. Manufacturing costs are largely fixed by the technology of printing and binding, and the cost of paper. Distribution costs are already a low proportion of overall costs, so substantial reductions would be difficult. Of the 20 percent spent on marketing and sales, 65 percent is for salesmen's and inservice consultants' salaries, departmental managers' salaries, catalogues and magazine advertising. An additional 15 percent is for free copies. The remaining 20 percent (or 4 percent of the total) is for salesmen's and consultants' travel and entertainment expenses. Reduction of the sampling is the most obvious category for reduction, but the standard practice in the industry is liberal. Thus, it would be difficult for any single firm to follow a different policy. Second, investment could be increased if schools were willing to spend more on curriculum materials. However, this would require reallocation of school district budgets. School districts are currently spending less than one percent of their budgets on materials.

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[*] Because this figure of $50 million is based on data from only 29 of the largest publishers, the actual figure is somewhat higher. But the error is not great because the report from which this figure was btained estimates total industry revenues to be about $800 million s compared to the total of $527 million in Table ___.

Level Within Subject Area. Because the school curriculum is compartmentalized into a large number of subject areas, this $50 million investment in new products is highly fragmented. As for the overall level of investment in new products, the approximate amount than can be spent within a subject area is determined by total revenues in that subject area and the costs of selling, manufacturing, and distributing the materials produced. Since these costs are approximately the same in all subject areas, the amount that can be spent on new product development in a subject area is about 10 percent of the revenues in that subject area. For a given firm, the amount will be proportionately smaller depending on the market share in that subject area that a new curriculum is projected to reach.

Some *estimates* of the amounts that *leading publishers* in a subject area can afford to invest in new products are shown in Table ___. These data are based on a number of assumptions and other data that has previously been presented in this report. First, we assume that 10 percent of revenues are invested in new product development. Second, we assume that the leading publishers in a subject area are the ones accounting for the first 50 percent of classroom usage. The numbers of these publishers in selected subject areas was shown in Table ___ in Chapter II. We assume for the purposes of our calculations that these leading publishers have equal market shares.

Third, since data are not available for revenues by subject area at the high school level, we assume that revenues are distributed according to student enrollments by subject area within major subjects such as math, science, and social studies. This assumption is valid to the extent that books in different subject areas are sold at approximately the same price and are used for similar proportions of the time in classrooms. Finally, we assume that the lifetime of a publisher's product is five years so that revenues accumulate over this period.

The results in Table ___ show the disparities in what leading publishers can afford to invest in different subject areas. The amounts range from several million dollars in elementary reading and mathematics, which are the two largest markets, to a few hundred thousand dollars in the subject areas within secondary science where the markets are much smaller. However, these elementary curricula are for grades K-6, so that the amounts available per grade level in reading and mathematics are about a few hundred thousand dollars, which is approximately the same as in secondary science. Thus, we find that the market and cost structure yields on the average about several hundred thousand dollars per grade level over a five year period for leading publishers to invest in new product development

Costs of Development. Whether this level of investment capability actually constraints publishers from investing in the development of highly innovative curricula requires estimating the relationship between development costs and the innovativeness of a curriculum. The faster that these costs increase with innovativeness, the more constraining this level of investment is on publisher's capability for developing innovative curricula.

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Table

ESTIMATED INVESTMENT OF EL-HI PUBLISHERS IN NEW PRODUCT DEVELOPMENT BY SUBJECT AREA, 1975

(millions)

Subject Area	1975[*] Revenues	Student[**] Enrollment	Estimated Annual[†] Investment in New Products by All Firms	Approximate[††] Investment in a Subject Area by Leading Firms Over a Product's Lifetime	Estimated Investment per Grade Level
Elementary (K-6)					
Reading	$135.7	--	$13.5	$4.2	.6
Mathematics	70.0	--	7.0	4.3	.6
Science	35.1	--	3.5	1.8	.3
Other	99.1	--	9.9	NA	NA
Secondary (9-12)					
Mathematics:	20.8	13.2	2.08		
Algebra					
Elementary		*1.9*	*.30*[x]	.75	.75
Intermediate		*1.2*	*.19*[x]	.48	.48
Advanced		*1.4*	*.06*[x]	.16	.16
Other		*9.7*	*1.53*	NA	NA
Science:	19.4	12.4	1.9		
Biology, 10th grade		*2.7*	*.4*[x]	.3	.3
Chemistry, 11th grade		*1.0*	*.2*[x]	.2	.2
Physics, 12th grade		*1.4*	*.1*[x]	.1	.1
		8.3	*1.30*	NA	NA
All other subjects	115.5	NA	11.5	NA	NA
Total	492.2	--	49.2	--	--

SOURCES: [*]"Industry Statistics," Association of American Publishers, New York, 1976, Tables F3 and F4. Data are for 23 publishers who reported.

[**]Logan Osterndorf, "Summary Offerings and Enrollments in Public Secondary Schools, 1972-1973," Department of Health, Education, and Welfare, National Center for Educational Statistics, 1975, Table A.

NOTES: [†]Annual investment in new product development by all firms is estimated to be 10 percent of total revenues in a subject area.

[††]Total investment by each leading firm in a subject area is estimated to be annual investment by all firms over five years divided by number of publishers in subject area having a total of over 50 percent of the market. Market shares are shown in Table 6.

[x]Annual investment in subject area is assumed to be proportional to enrollments in a subject area as a proportional of total enrollments in subject.

But determining a precise relationship is difficult because there is no obvious definition of the degree of innovativeness of a curriculum. One source of evidence is the developmental costs of the NSF curriculum projects. As shown in Table __, these costs have ranged from about six hundred thousand dollars per grade level for the elementary science programs, which is about twice publishers investment capabilities, to a few million dollars per grade level for the early high school science projects, which is over ten times publisher's investment capabilities.

It has been asserted that the NSF curricula could have been developed more cheaply through some other method but this is not obvious. One major publisher who started in the early 1949s to develop a "new mathematics" curriculum that was similar in many respects to SMSG, spent $10 million over a 20 year period and nearly failed. The matehamtics department editor of this publishing firm has been quoted as saying that, "What saved our lives was World War II, nuclear energy, automation, Sputnik, and the School Mathematics Study Group..."* As shown in Table __, SMSG spent 40 percent more than this publisher but for programs spanning all the grade levels from kindergarten through twelveth grade. For grades K-8, ths SMSG's cost was approximately the same at what this publisher spent.

One of the major reasons why the development costs of the NSF curricula have been higher than what publishers normally invest is the expense of the school-level trials that were conducted for the purpose or revising preliminary revisions of curriculum materials. In fact, one of the reasons why the development costs of the early high school projects were substantially higher than the later elementary school projects is the larger number of trial centers that were supported as compared to the later projects. The lack of investment funds inhibits publishers from trying out materials in the schools for revision purposes

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*Hillel Balck, *The American School Book*, William Morrow, New York, 1967, p. 71.

before market introduction and with rare exception they do not. But, without trials, the risks of investing in highly innovative curricula are unacceptable. Thus, one of the ways in which the investment funds available to publishers limit their developmental capacity is in not being sufficient to allow for the try out and revision of new materials before market introduction.

Incentives Within A Subject Area

Apart from development costs, a publisher also has to consider how much each innovation incorporated in a new program will potentially reduce the market share that the program will gain. The lower this market share, the less a publisher can afford to invest in development.

Effect of Curriculum Regularities

We have already discussed how the innovations of changing subject matter, basing a program on enactive materials, or incorporating features that entail substantial teacher behavioral change all tend to reduce this share. What we have not discussed is that with each increment in innovativeness in each of these dimensions or in combination the reductions in market share become larger because the populations of teachers who will adopt these innovations become disproportionately smaller. Furthermore, this effect is greater the higher the degree of regularity in the school curriculum in the dimension in which innovation is attempted. Greater diversity in the school curriculum would allow publishers to develop programs for a particular segment of the market and still earn sufficient revenues. The net effect on publisher's decisions is that there are strong incentives to develop programs for the modal school curriculum.

As an illustration of this general phenomenon, data were presented in Fig. __, showing that the subject matter backgrounds of high school science teachers are highly peaked around 40 semester hours of coursework in their specialty. As the level of training increases by increments of five semester hours, the successive numbers of teachers having each level of additional training falls rapidly. Assuming that 40 semester hours of training represent certain subject matter competencies, these data illustrate how the market share of a science program can decline rapidly with additional innovations in its subject matter content. The magnitude of this effect was illustrated in the same section in which these data were presented by the small differences in the subject matter content of the BSCS Yellow Version as compared to the Blue and Green Versions, which resulted in the Yellow Version having approximately double the sales of the two other Versions. A similar argument can be made for innovations in all other dimensions of the school curriculum.

Market Entry. A further disincentive to innovation is a subject matter area is the difficulty of market entry and especially when one or two publishers have a lion's share of the market. There are two major problems. First, publisher's experience has been that a long time is required to establish a new program's creditibility in the market. Publisher's believe that this creditibility is established through an informal, word-of-mouth process among teachers and curriculum supervisors that a program is educationally sound and practicable in the classroom, and through vigorous selling efforts. Once on top, a program gains a reputation for being the most successful that makes it easier to sell. Establishing this creditibility would be easier if school districts relied on performance evaluation data but they do not. Then, there would be incentive for publishers to present such evidence as a means of convincing local personnel of a program's effectiveness.

Publishers having a leading market share already have this creditibility but not much incentive to abandon their successful programs for more innovative ones. Publishers not having a leading share have greater incentive to try breaking into the market with an innovative program but face the difficult problem of establishing its creditibility soon enough to earn adequate return on investment.

The second problem is that publishers having a leading market share can afford to invest in features that increase a program's attractiveness to teachers. These features include a longer text, covering more subject matter topics; more frequent revisions of text materials, to eliminate parts that teachers do not like and add others that they do like; a more extensive teacher's guide, student tests, transparencies, film strips, and other aids to lighten the classroom load; optional packaging formats for different usage situations; and so forth. All of these features broaden the appeal of a basic program but require additional investment cost that is difficult to justify when market shares are small. Both of these difficulties in entering a market further bias the new product decisionmaking process to the modal school curriculum.

Influence on the School Curriculum. These factors that make market entry difficult may also explain why there has been a tendency in the past for leading programs to gain market shares of three-quarters or more in some subject areas and to hold such shares for years. The explanation would be that as the reputation of a leading program spreads, more teachers decide to adopt it and through use become "comfortable" with its curriculum content. This decreases the number of teachers seeking alternatives to the leading program and hence the market potential for alternatives which further reduces the ability of other publishers to continue investing in

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their alternative programs or to attempt breaking into the market with a new alternative. With this model, market forces not only bias the new project decisionmaking process but also affect the school curriculum in ways tending to increase its regularity and stability, which further affects investment in new programs.

Summary

In summary, there are three main factors affecting new product development in publishing tending to favor maintenance of the existing school curriculum and convergence to existing regularities. First, the small proportion of school district funds allocated to purchasing materials limits the funds that publishers have available to invest in new products to a level apparently less than what is required to develop highly innovative programs. Second, the incentives within subject areas are to invest in programs that appeal to the largest number of teachers which further reduces the amount that publishers can afford to invest in highly innovative programs, since these programs typically appeal to only small numbers of teachers because of regularities in the school curriculum.

Or, in the terminology introduced in Chapter II, institutional factors in the curriculum policymaking system tend to limit the publishing industry to the production rather than the development level of resource-providing capability.

In concluding that incentives in publishing tend to favor production rather than development, leading publishers have the advantages in the market of established creditibility of their programs among teachers and curriculum supervisors and curriculum personnel, and more funds to broaden the appeal of their programs by adding extra features, which further reduces the incentive for other publishers to enter into the market with highly innovative programs.

In concluding that there are strong incentives in publishing to develop programs for the modal school curriculum, we are not implying that publishers never develop highly innovative programs nor that they are all extremely conservative. On the contrary, one example of a major investment by a publisher in an innovative mathematics program has already been given and there are many more examples that could be cited. Furthermore, there are substantial differences among firms in their willingness to accept risks. Some firms prefer to be at the leading edge of curriculum change through offering more innovative programs, while others are very conservative. Several publishers have subsidiary companies that are oriented to innovative programs. The conclusion is only that the bias of market incentives is strongly in favor of programs that are readily acceptable to large numbers of local school districts and teachers since the market potential of programs that are highly innovative in the dimensions of subject matter content, required teacher behavior, and/or materials format is typically very low.

Market incentives force publishers to be cost conscious and pragmatic in deciding on changes to incorporate in new programs. From their long experience in dealing with schools, publishers have a keen sense of what teachers will accept and find practicable, and rely on this knowledge in designing new programs. Features that in publishers' experiences will not be workable in the school environment are rejected. Publishers know that costly programs will not sell in the schools, no matter how educationally sound and innovative. In contrast, many developers in national curriculum projects have not had to fact market realities over a long period of time and may not realize some of the practical consequences of their ideas. The grasp that publishers have on the realities of curriculum in the schools is indicated by the fact that although federal funding for national curriculum development has been at about the same level as the approximately $50 million a year spent by publishers, their programs overwhelmingly dominate in the market.* Federal expenditures for national curriculum development include the approximately $15 million per year from NSF, and a substantial proportion of NIE's budget of approximately $70 million, plus support from other federal agencies.**

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*Data showing the market shares of BSCS which has been one of the most successful federally developed curricula will be shown in Chapter VI.

**"The Status of Education Research and Development in the United States - 1976," National Institute of Education, Washington, D.C., Table 3.3.

Chapter VI

EFFECTS OF NATIONAL CURRICULUM DEVELOPMENT ON INSTITUTIONS IN THE CURRICULUM POLICYMAKING SYSTEM

As indicated in the conceptual framework in Chapter II, another potential effect of national curriculum development can be to cause institutional change in the curriculum policymaking system. The two major kinds of possible institutional change are in organizational factors inhibiting the incorporation of innovations from national curriculum projects and in the level of innovative activity. Analysis of institutional changes in publishing, state adoption boards, and local school districts are presented in this Chapter.

INSTITUTIONAL CHANGES IN PUBLISHING

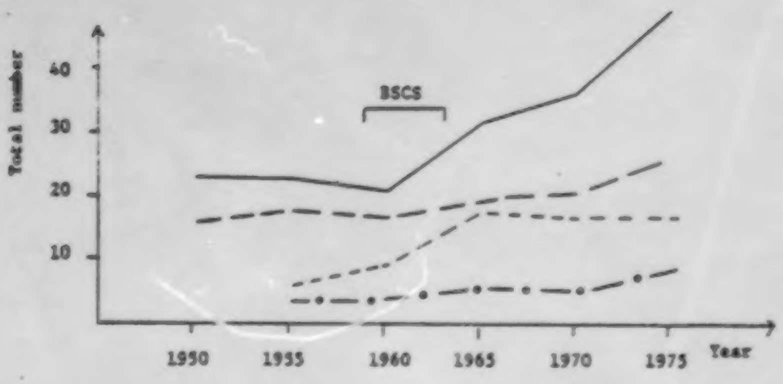
The institutional changes in publishing that we will mainly consider are in the level of innovative activity since data on the organizational factors that we discussed in Chapter IV of investment in new products, and capacity for manufacturing and distributing curricula based on enactive materials are difficult to obtain. In publishing, the level of innovative activity concerns both rates of new product introduction and the balance between the production, development, and integration modes of developmental activity. The desired institutional effect of national curriculum development would be to shift innovative activity in the publishing industry to the developmental and integration modes.

The ideal analysis indicated by the conceptual framework is to determine the number of new products introduced over time by different publishers, classified by the modes of innovative activity, but the effort required to precisely define these categories and collect the necessary data is beyond the means of this study. Instead, we will present series of partial analyses guided by this ideal model. First, we will analyze the effects of national curriculum development on rates of new product introduction irrespective of differences in the mode of innovative activity. This will provide a gross measure of the effects of national curriculum development on innovative activity. Second, we will analyze the effects of national curriculum development on the numbers of publishers in the market in a subject area as an indication of changes in the distribution of market shares among firms. We assume that increases in the number of publishers in the market increases the number of publishers who can afford to invest in substantial alternatives to existing curricula which is one characteristic of the development mode. Data on the number of firms on the market are not sufficient to conclude how different the programs introduced by the existing firms are from existing programs, but indicate a tendency to the developmental mode. We will also present data on actual changes in market shares in the one subject area (high school biology) where data could be obtained. Third, we will describe changes in the modes of innovative activity in more detail in the four publishers where interviews were conducted.

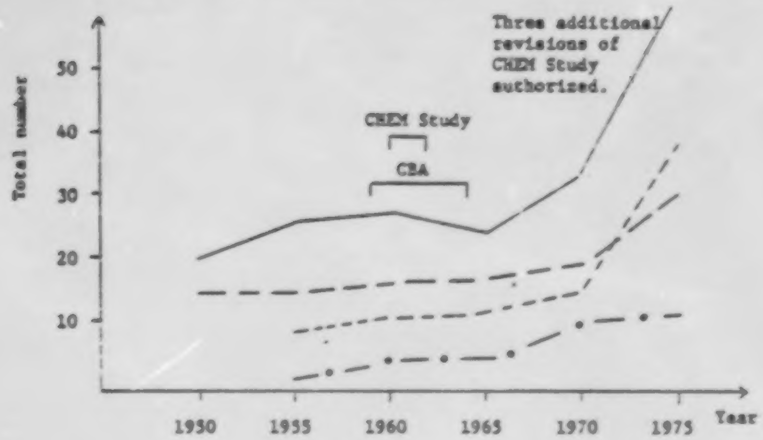
New Product Introduction

As shown in Figs. ___, ___, and ___, the NSF curriculum projects have caused the rates of new product introduction to more than double in most science subject areas. These data were obtained by compiling the numbers of basal curricula on the market over the years by subject area from 1950 to 1975 as listed in a generally used catalogue of curriculum projects for elementary and secondary schools. In compiling the data for [illegible] ___,___, and ___, basal products were defined to be

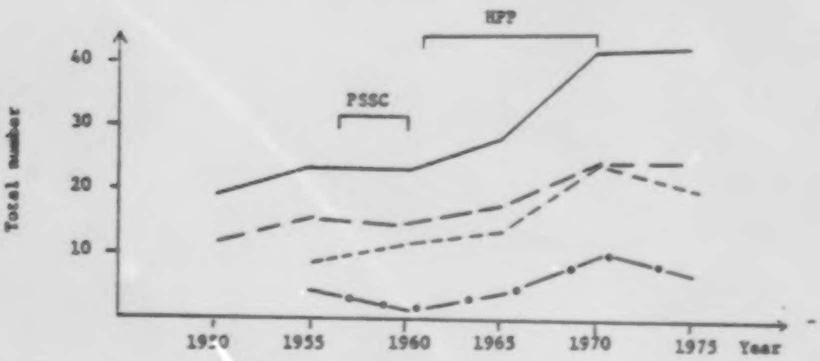
High School Biology Curricula (10th Grade)



High School Chemistry (11th Grade)



High School Physics Curricula (12th Grade)



SOURCES: *El-Hi Textbooks in Print, 1975*, R. R. Bowker, New York, 1976.

NOTES: —• Number of publishers entering the market in the previous five years. —— Number of basal programs in a subject area in the previous five years. — — Number of publishers offering these basal programs. --- Number of new basal programs in a subject area in the previous five years.

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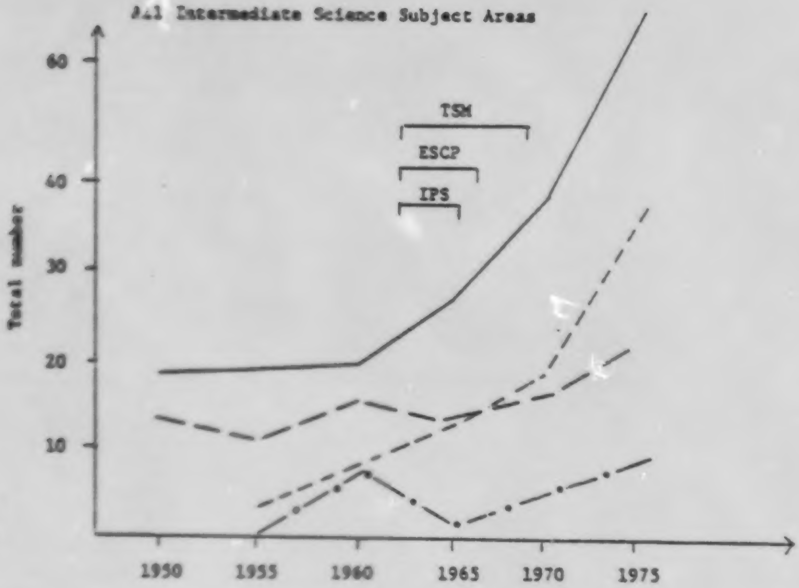
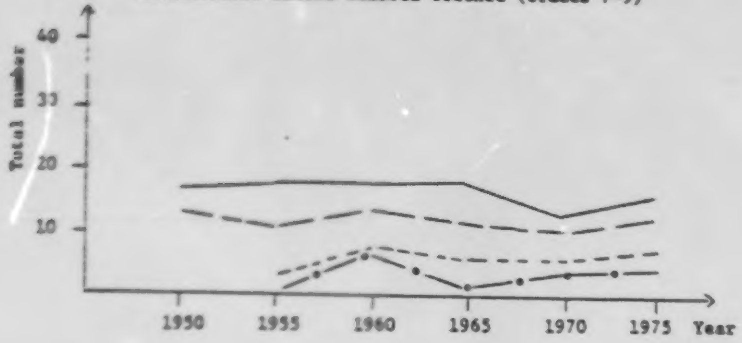
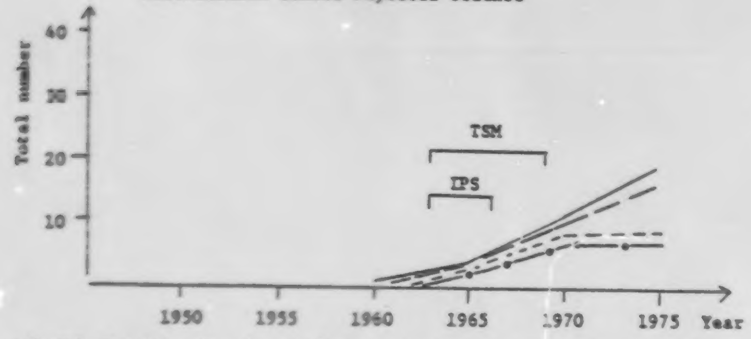
All Intermediate Science Subject Areas



Intermediate School General Science (Grades 7-9)



Intermediate School Physical Science



SOURCES: *El-Hi Textbooks in Print, 1975*, R. R. Bowber, 1976.

NOTES: ——Number of basal programs in a subject area.— —Number of publishers in a subject area. ----Number of new basal programs in a subject area in the previous five years.

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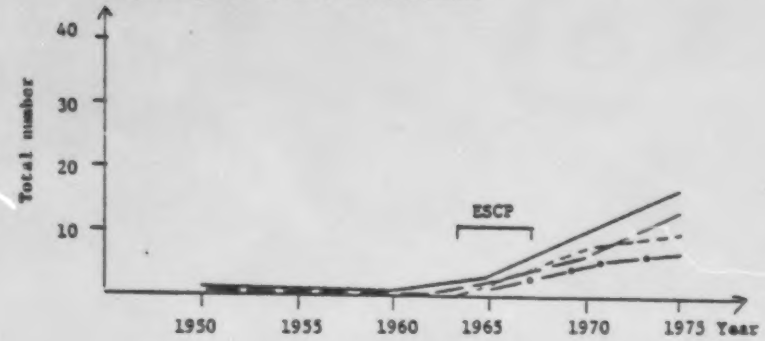
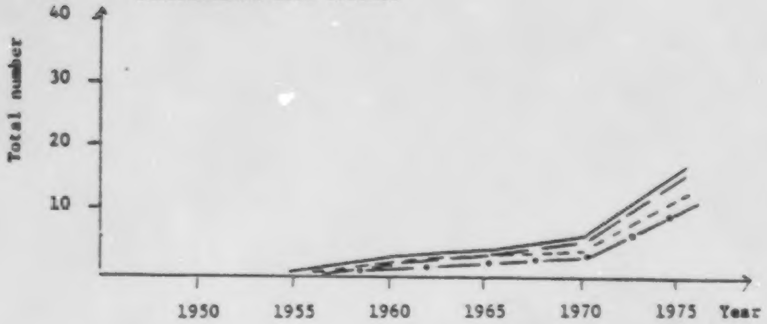
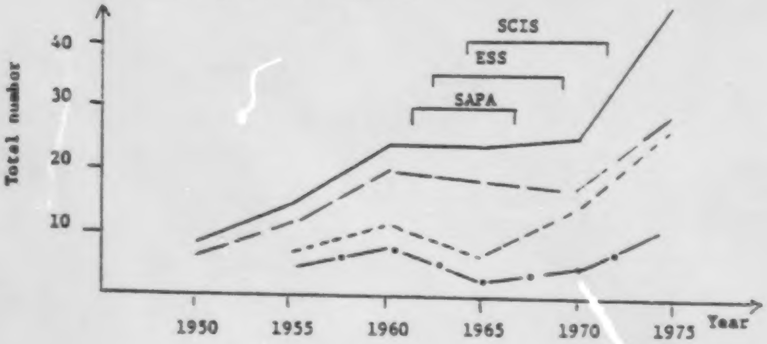
Intermediate School Earth Science



Intermediate Life Science



Elementary Science Curricula



institutional materials in any format capable of being used as a complete course of study in a subject area. Materials that are clearly science dictionaries, review texts, or which cover only a limited range of topics as indicated by the title, were rejected as basal programs. Only first editions were included even though revisions of existing products are sometimes substantial enough to qualify as "new products." The magnitude of the analytical effort that would be required to assess the degree of change in each edition was beyond the means of this study.

At the high school level, the rate of new product introduction has increased in all three subject areas of biology, chemistry, and physics since the introduction of the new science curricula. In 10th grade biology the increase is from 1.5 new products per year before the BSCS project to 3.2 per year since the project was completed. The difference is larger in chemistry and is from 2.0 to 5.4 new programs per year. The increases in physics are from 1.8 to 3.8 per year in rates of new product introduction but in recent years have begun to decline, even though the Project Physics curriculum was introduced in 1970. As shown in Fig. 8, the high school physics market has not diversified as much as chemistry or biology since HPP.

The increases in rates of new product introduction exhibit larger discontinuities in biology and chemistry than in physics, which may be related to differences in the number of NSF curriculum alternatives introduced. The discontinuity is largest in chemistry where five new alternatives were introduced: the CBA curriculum, the original CHEM Study text (since revised), and three additional authorized revisions by publishers. In biology, there are the three BSCS Versions discussed, plus a curriculum for the less academically successful (Biological Science

Patterns and Processes), and a laboratory-based curriculum (Laboratory Blocks). In contrast, there was only one authorized version of the PSSC curriculum until recently when the Project Physics curriculum was introduced. The ways in which the availability of larger numbers of new alternatives lead to greater numbers of publishers in the market will be discussed later in this Chapter.

At the intermediate level, there have been increases not only in the rates of new program introduction, but also a shift in subject matter organization from general science to a discipline-orientation. Prior to the NSF science curricula there were practically no discipline-oriented alternatives available and now there are more than general science alternatives. The rate of new program introduction in all subject areas has increased from 1.2 to 6.2 per year considering all subject areas together, and from zero to approximately 1.7 per year in physical and earth science where NSF projects have been supported.

The effects of the national curriculum projects are least clear in elementary science, since the market was growing rapidly during the ten years prior to the initiation of NSF funding. The rate of new program introduction has increased from 1.8 to 2.6 per year, but these increases may be due to the deferral of decisions by publishers to enter the market during the period when the elementary science curricula were being developed. As shown in ~~Fig.~~ T. 6.1 the rate of new program introduction actually declined during the early years of national development.

But the rate of growth during the 1950s might not have continued into the 1970s, if the national projects had not been conducted. Elementary science was an attractive area for market entry in the 1950s because of the emphasis on science and technology in society and the relatively small number of established programs in the market. By the 1960s, many

Table 6.1

RATE OF NEW PROGRAM INTRODUCTION IN SCIENCE SUBJECT AREAS, 1950-1975
(average number per year introduced)

Subject areas and NSF curricula	Time period		
	Prior to initiation of NSF curriculum development	During NSF curriculum development	After introduction of NSF curriculum
High School Science			
Biology			
BSCS	+1.5 (1950-1960)	+3.4 (1960-1965)	+3.2 (1965-1975)
Chemistry			
CHEM Study	+2.0 (1950-1960)	+2.4 (1960-1975)	+5.4 (1965-1975)
Physics			
PSSC	+1.8 (1950-1955)	+2.4 (1955-1960)	+3.8 (1960-1970)
Intermediate Science			
General Science	+1.0	+ .6	+1.3
Physical Science			
IPS, TSM	.0	+ .8	+1.8
Earth Science			
ESCP	.0	+ .4	+1.6
Life Science	+ .2	+ .2	+1.5
All Science	+1.2 (1950-1960)	+2.0 (1960-1965)	+6.2 (1965-1975)
Elementary Science			
SAPA, ESS, SCIS	1.8 (1950-1960)	2.1 (1960-1970)	2.6 (1970-1975)

SOURCE: Fig. ___.

more programs were available and then in the 1970s science fell into public disfavor. Despite this disenchantment with science, sales of elementary science products have grown faster in recent years than the market as a whole, and this may be due to the NSF curricula. In contrast, reading and mathematics have increased at about the same rate as the overall market, while social studies has decreased. English has increased by an even larger percent than science, although from a smaller initial level. The reason may be the broad social concern with poor writing skills to which the schools are responding by placing more emphasis on English. The jump in reading sales in 1974 is due to a large number of state adoptions.

Other possible explanations of these changes in curriculum markets are greater rates of growth in market size in the 1960s and 1970s than in the 1950s, due to increasing numbers of students and the changes in ownership patterns in the industry during the 1960s, when many firms were merged or bought out by larger companies, who may have supplied additional funds for investment.

There are five main reasons for rejecting these explanations. First, the years in which rates of new product introduction began to increase correspond with the years in which the new science curricula were introduced into the market. In the high school science, the market began to grow in the early 1960s as the new high school science curricula became available, while the growth in the intermediate science markets does not begin until the late 1960s, when the intermediate science curricula were introduced. Second, the creation of new subject areas in intermediate science is unlikely simply because of either market growth or new funds for investment from parent firms. Furthermore, there have not been any national projects in the intermediate life science and growth in this subject area lags the growth in physical and earth science. Apparently, the introduction of the new physical and earth science curricula have created a need for a life science program and the publishers have responded. Third, there has been practically no change in rates of entry in general science where no national curriculum projects have been supported. Fourth, the data appearing in Table 6.2 show that the numbers of students enrolled in science have not increased by much larger amounts in the 1960s and 1970s than in the 1950s, indicating that increased rates of market gorwth are not the reason for the increased rate of new product introduction. Data on student enrollments are not available for the intermediate level but would probably show similar continuities. Enrollments at the elementary level have actually declined in recent years. Lastly, publishers said during our interviews with them that the high expectations for el-hi publishing in the 1960s, which prompted the wave of changes in ownership, have not been realized, which has discouraged parent companies from financing major expansions in their el-hi publishing divisions during the 1970s. Yet, rates of new product introduction have increased more in the 1970s than in the 1960s.

Market Shares

The increases in rates of new product introduction are paralleled by growth in the total number of publishers in the market, indicating that market shares have been redistributed and that therefore, more publishers have sufficient funds to invest in substantial alternatives to curriculum products that dominate in the market. As shown in Table 6.3, the growth per year in the total number of publishers in the market has been larger in every science subject area in the years after the introduction of new science curricula as compared to previous years. At

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Table 6.2

MARKET GROWTH IN HIGH SCHOOL SCIENCE SUBJECT AREAS 1948-1972
(thousands)

Subject Area	Course Enrollments			Total Increase	
	1948	1960	1972	1948-1960	1960-1972
Biology	1000	1800	2900	800	1100
Chemistry	410	750	1000	210	250
Physics	290	400	580	110	180

SOURCES: National Center for Educational Statistics, "Summary of Offerings and Enrollments in Public Secondary Schools," NCES 76-150, Washington, D.C., 1975.

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Table 6.3

NUMBER OF PUBLISHERS OFFERING PROGRAMS IN SCIENCE SUBJECT AREAS
(average increase in number per year)

Subject areas and NSF curricula	Period prior to initiation of NSF curriculum development	During development of NSF curricula	Period after introduction of NSF curricula
High School Science			
Biology			
BSCS	+ .1 (1950-1960)	+ .4 (1960-1965)	+ .7 (1965-1975)
Chemistry			
CHEM Study, CBA	+ .2 (1950-1960)	0.0 (1960-1965)	+1.5 (1965-1975)
Physics			
PSSC	+ .8 (1950-1955)	-0.2 (1955-1960)	+ .9 (1960-1970)
Intermediate Science			
General Science	+ .1 (1950-1960)	- .4 (1960-1965)	+ .1 (1965-1975)
Physical Science IPS, TSM	+0.0	+ .8	+1.3
Earth Science ESCP	0.0	+ .4	1.2
Life Science	.2	.2	1.1
All Science	.2	- .4	.4
Elementary Science			
SAPA, ESS, SCIS	+1.3 (1955-1960)	- .2 (1960-1970)	+2.4 (1970-1975)

SOURCES: Figs. ___, ___, and ___.

the high school level, the growth has again been the largest in biology and chemistry, and the smallest in physics. As the intermediate level, the growth rate in the number of publishers in the market has been from zero to about 1.25 per year in physical and earth science where the NSF projects have been supported, and from 1.3 to 2.4 per year in elementary science. The declines in the number of publishers in the market during the development of NSF curricula show the extent to which the prospect of major new alternatives in a subject area caused firms to withdraw all of their products from the market. The effects of the national curriculum projects on actual market shares may be even more dramatic than indicated by these data on numbers of publishers in the market as shown by the data in Fig. -1 for the 10th grade biology market.* These data shown that student usage of the Modern Biology program has fallen over the years since the BSCS Versions have been available from approximately 80 percent of the market (a share that had been held for many years), to about 25 percent of the market. The three BSCS Versions have about 20 percent of the market, with the Green Version having about 10 percent, the Yellow Version six percent, and the Blue Version four percent.** In addition, data in the source referred to in Chapter II show the BSCS Laboratory Blocks curriculum is being used by about as many teachers as are using BSCS Green and the two other BSCS basal programs--Patterns and Processes and Invitations to Discovery--by about half as many teachers as are using BSCS Blue.

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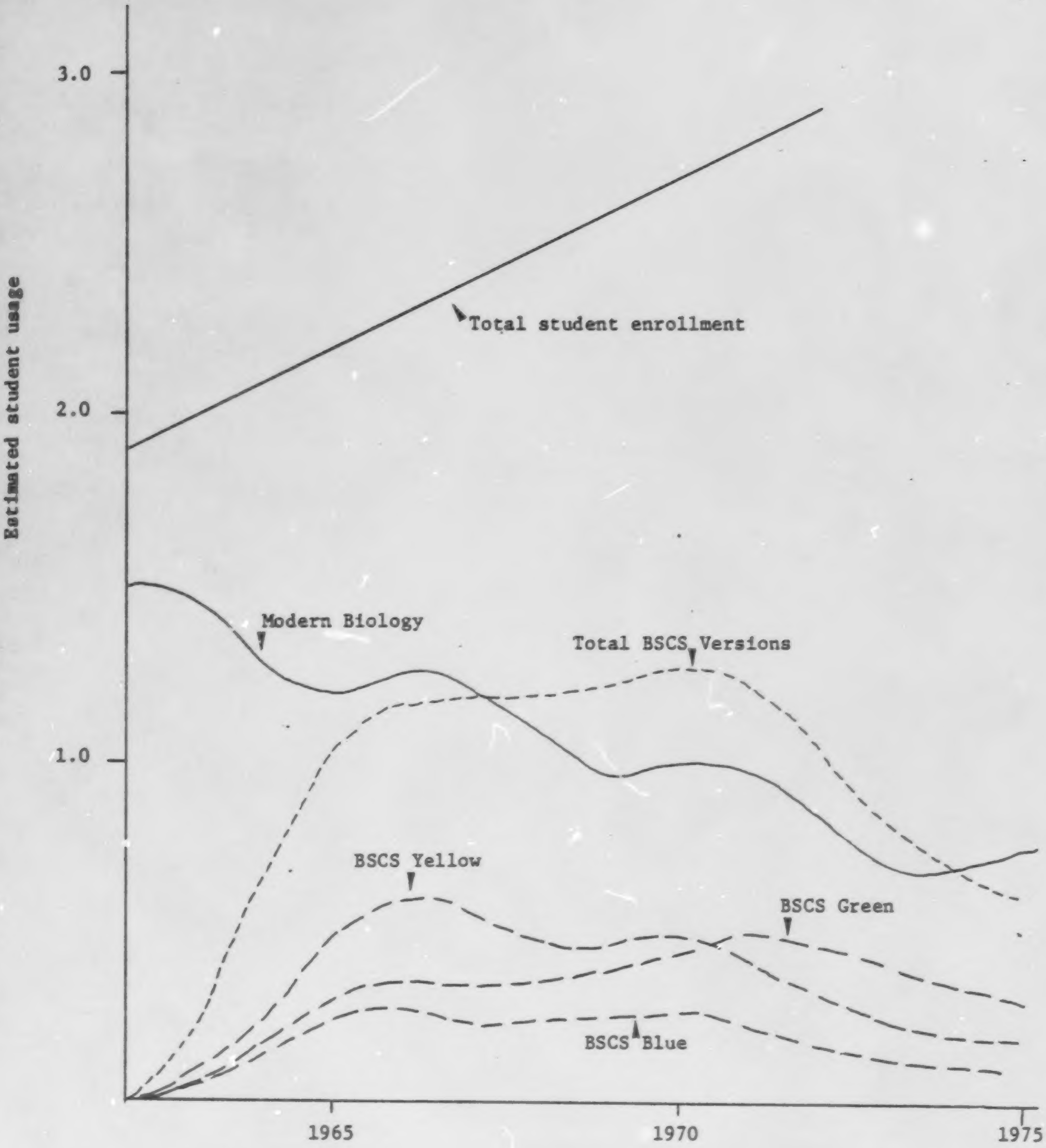
*The method used to obtain the estimates in Fig. ___ is described in Appendix A.

**These percentages were calculated from Fig. ___ by extrapolating student enrollments in a straight line from the data point in 1972. Based on some unpublished work, Robert Howe of the Center for Science, Mathematics and Environmental Education at Ohio State University estimates that enrollments in high school biology may have fallen slightly in the 1970s which would increase the percentages given in the text.



NOTE: Student usage was estimated from sales data supplied by Holt, Rinehart, and Winston and BSCS, Inc., using a procedure described in the text. Course enrollment data are from U.S. Office of Education, op. cit.

Fig. 4 -- Estimated student usage of BSCS versions and Modern Biology curriculum materials, 1963-1975

Data in this same source also show that three other publishers have products that are being used by numbers of teachers between the numbers who are using BSCS Green and Yellow, and one other at a level slightly below BSCS Blue. Thus, available evidence indicates that the BSCS curriculum project has changed the biology market from a situation where one publisher had a product that had 80 percent of the market and had had this share for years, to a situation where 80 percent of the market is about equally divided among this same product, the five BSCS curricula, and four other publishers' products.

For reasons discussed more fully in Appendix A, these estimates of student usage only indicate *trends in usage and not precise figures* for the true numbers of students in any given year. The estimates are based on textbook sales data in each of the years shown and survey data on actual usage of the BSCS Versions in 1970. Therefore, the estimates of student usage are most accurate for that year. As discussed in Appendix A, the estimates are least accurate in the early years following the initial release of the BSCS Versions. Estimated BSCS usage in these early years is probably higher than the true figures.

These results on the effects of BSCS on the high school biology market add to our conclusions in the previous chapter on the importance in achieving curriculum change of carrying development through the production of materials. The three publishers who won the rights to publish the BSCS materials were able to enter the market and be successful with major alternatives to Modern Biology without having to bear the risks of development, which would have been difficult for them to do since they did not have substantial market shares. Furthermore, the creditability of the BSCS Versions was already established because of BSCS's prestigious reputation. If the BSCS project had only issued guidelines and perhaps prototype materials, then publishers would still have had to invest substnatial amounts in developing finished materials. As analyzed in the previous Chapter, the Modern Biology publisher responded to the prospective success of these alternatives by incorporating many of the BSCS innovations in order to forestall loss of sales to teachers preferring the content of the new curricula. From 1963 to 1970 these four curricula apparently gained almost all of the tenth grade biology market, since the total student usage of these programs accounts for essentially all of the estimated enrollment. Then in 1970, total sales of these four curricula began to fall in relation to the total market as curricula introduced by other publishers began to be more successful for probably two reasons. First, the changes in Modern Biology raised its conceptual level and shifted its content away from the old norms, which left a bigger opening at the lower end of the market for other publishers to enter; and in fact, some of the products that have gained a substnatial market share since 1970 are for this end of the spectrum in subject matter content and cognitive level. Second, success of the three BSCS curricula demonstrated that there is more than one way to teach biology, which created a climate of change at the local level that led to greater receptivity to new alternatives.

Some publishers who have won publication rights to new curricula have used the opportunity to build product lines and staff capability in a subject area that they previously did not have. Of the four publishers where we conducted interviews, the two that have published NSF science curricula each now have several successful science programs and greater staff capability as shown in Table 6.3. The publishers said that the NSF curricula provided the necessary image to enter the market as a publisher of quality science curriculum, hire good editorial staff,

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Table 6.7

IMPROVEMENT IN THE MARKET POSITIONS OF FOUR PUBLISHERS WHERE INTERVIEWS WERE CONDUCTED

Publisher	Areas Combined		
	Products on the market in 1960 in all science subject areas	Products on the market in 1975 in all science subject areas	
	2nd edition or more	2nd edition or more	Used by 1 percent or more of teachers
Two NSF curricula published			
A	0	2	5
B	3	3	4
No NSF curricula published			
C	1	3	1
D	0	1	0

SOURCES: *El-Hi Textbooks in Print, 1975*, op. cit.; *El-Hi Textbooks in Print, 1960*, op. cit.; P. Kenneth Komoski, op. cit.

and to attract quality authors for producing other products. In 1960 one of these publishers did not have any products that they had been able to sell for more than one edition. The other publisher had three products that they had been able to sell for more than one edition, but the market shares were very small and were considered outmoded by teachers. Both of these publishers said they benefited greatly from having published two rather than only one NSF curricula in this building effort, because of the greater visibility in the market and opportunity for editorial staff work provided. One of these publishers hired several staff from one of the NSF elementary science projects and produced a competing product utilizing enactive materials. Neither of the two other publishers that are interviewed who have not published any national curricula, have grown as much. In Table 6.5, we consider the data based on sales in the third column to be a better measure of market success than the data in the first and second columns concerning the number of products in more than one edition. A publisher can carry a product into a second edition in an attempt to gain a market share even though the first edition has been a total failure.

Development Capability

While indicative of change toward the developmental level of innovative activity in the publishing industry, these data on new product introduction and market shares do not fully show the extent to which development has been institutionalized as the mode of innovative activity. As a first cut at making this assessment, we will describe the extent of change in the four firms where we conducted extensive interviews. As discussed in the introductory section of Chapter IV, these firms were selected so that two have been the publishers of two or more NSF curricula and two have not published any NSF curricula. This allows examination

Table 6.5

PUBLISHERS SALES IN SELECTED ELEMENTARY SUBJECT AREAS
(dollars in millions)

Subject Area	1972	1973	1974	1975	Percent Change 1972-1975
Reading	106	110	136	136	+28
Mathematics	53	58	58	67	+26
Science	24	22	28	35	+38
English	16	20	23	30	+87
Social Studies	21	21	20	19	-10
TOTAL ELEMENTARY	318	344	379	411	+29

SOURCE: "Industry Statistics-1975," and "Industry Statistics-1973," Association of American Publishers, New York, Tables F3 and T1. Subject area data are for 23 leading publishers in 1972-1973 and leading publishers in 1974-1975.

of differences in effects due to direct involvement in publishing a national curriculum project.

Inhouse initiative. In all four of the firms where we conducted interviews, publishers have been assuming a stronger role in determining the curriculum content of their products and managing the generation process since the late 1950s. Prior to the national curriculum projects the new product generation process generally followed the classical author/editor model that still largely applies in the tradebook side of the publishing industry, where authors are responsible for the content of new products and the inhouse staff only for journalistic quality and presentation. Authors were expected to respond to the publisher's concerns about what would sell in the market but largely had a free hand in determining subject matter objectives and content. Inhouse editorial staff polished up the writing in manuscripts submitted by the authors and did layout work. The role of inhouse staff has changes to where the subject matter objectives and content of new products are now usually formulated by teams of inhouse editorial staff and authors, although some manuscripts that "come in under the door" are still acceptable as the phrase goes in the industry. Furthermore, inhouse editorial staff may do much of the writing to the course outlines produced. Far more often than in the past, an inhouse staff person rather than an outside author holds final responsibility for the substance of new products. These changes represent a shift in the inhouse capability of publishers from strictly the production mode in the direction of development. The shift in the two publishers that had published NSF curricula was not any greater than in the two publishers that had not.

With the trend toward greater inhouse control of the product generation process, the editorial staffs in the four firms where we conducted interviews have grown in size and become more subject matter-oriented. Prior to the curriculum movement, editors had mainly editorial skills and little background in either education or a subject matter area. Many firms had an editorial pool and simply assigned editors to projects as they came along without regard to subject matter. Today, most firms have editorial staffs organized by subject areas and staff members are subject matter specialists first and then editors. Most have had several years of teaching experience, as compared to practically none in the past, and an advanced degree in some educational subject area (e.g., a master's degree in mathematics or science education).

The reasons for these changes appear at least partly, if not entirely, due to the national curriculum projects. The president of one of the publishing firms in which we conducted interviews said that the subject matter skills of his staff had been increased because of the "...tremendous emphasis on subject matter..." since the NSF projects. He said that since the NSF projects, subject matter had to be dealt with more precisely and that there are more subject matter alternatives to consider. Both of these developments have required greater staff competence in judging the work of authors and in making choices in new product planning. Another, and probably stronger, reason is that inhouse staff capabilities have had to be increased because of the increased pressures to bring products to the market on time and within budget due to increased level of competition among firms that we discussed in the previous section. The publishers whom we interviewed all said that el-hi publishing has become more important. In order to exert this control inhouse staff capabilities have had to be increased. One respondent explained that "...in the old days when single publishers had control of individual markets, you were either that publisher and could afford to bring out new materials when the authors got them ready, or if you were not, you had to wait until their materials came out to see what they would be and then you responded."

Classroom Trials. Another indicator of change from production to development is the extent to which classroom trials of preliminary versions of materials have been integrated into the product generation process. We found that the two publishers that have published NSF curricula have experimented with but not fully incorporated classroom trials in their procedures for producing new curricula. One of these publishers has actually conducted full-scale development of an intermediate level science program, including two rounds of school-level trials with over 500 teachers and 50,000 students. Through participation in BSCS, a staff member learned about the development process and hired some BSCS staff as developers. Although this publisher continues to pilot some new products in a small number of classrooms, full-scale development has not been attempted again because of the expense involved and the unexpected difficulty that they encountered in gaining the cooperation of schools in conducting trials and later on convincing teachers that a genuine developmental effort had been undertaken.* The evidence that the program had been tested in the schools did not provide any advantage in the market and het required extra investment. Here we find that in order for development to be institutionalized in publishing, change has to occur in the inter-institutional relationship between publishers and local school districts, of schools accepting that publishers can be creditable developers of new curricula. The other publisher that had

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*Hulda Grobman, *Developmental Curriculum Projects*, F.E. Peacock, 1970, p. 30.

published NSF curricula conducts some trials mainly for the purpose of determining the practicability and effectiveness of any parts of new curricula that are highly innovative. The two publishers that have not published any NSF curricula have not conducted any school level trials and have no plans to do so.

Author background. Another potentially important area of institutional change that we decided not to pursue in this study is the background and experience of authors retained by publishers to plan and write textbooks and other instructional materials. The possibility is that because of the national curriculum projects publishers reach out more frequently than prior to the late 1950s beyond traditional circles to involve scholars from academic subject matter fields, in learning theory and child development and curriculum developers as the authors of new materials. One of the hoped for effects of NSF's support for national curriculum projects was that scientists would be more willing in the future than in the past to become directly involved in the improvement of the elementary and secondary school curriculum. In a 1963 article, Brownson and Schwab presented data showing that the proportion of high school science textbook authors having academic qualifications had declined from 48 percent in 1915 to 31 percent in 1955. The criterion of academic standing was listed in the publication American Men of Science.* The amount of work required to assemble a list of all the authors of textbooks available in the market precluded these kinds of analyses in this study but the effect is extremely important.

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*William E. Brownson and Joseph J. Schwab, "American Science Textbooks and Their Authors, 1915 and 1955," *School Review*, Vol. 71, No. 2, Summer 1963, pp. 171-179.

Inservice Support Capability

In addition to changes toward the developmental mode of innovative activity, publishers can also be providing more inservice support to local school districts in incorporating curriculum innovations, which would be an important increase in "integrative capability" as we have defined the term in this report.

Similarly to the situation for incorporation of classroom trials in the product generation process, the publishing firms where we conducted interviews have experimented with but have not been able to continue high levels of inservice support. One of the two publishers that has published NSF curricula established a department of five professionals to market, coordinate, and support a group of consultants capable of providing direct and continuing assistance to local school districts on a fee for service basis. This department had to be disbanded after a short period of time due to lack of sales. The other publisher of NSF curricula has invested substantial amounts in free consultant services and a number of curriculum resource centers for one of the NSF curricula that they are publishing. Also, they will be offering an inservice support on a fee-for-service basis with another new curriculum from one of NIE's Regional Laboratories that they will be publishing as an experiment. Neither of the two non-NSF publishers provide more than occasional consultant service and have no expansion plans.

The inservice effort of the publisher who has provided free consultant service and curriculum resource centers for one of the NSF curricula that they are publishing is an interesting example of how direct involvement of a publisher in a curriculum project can lead to institutional change. This inservice effort has been built upon the network of resource personnel and curriculum resource centers originally established by the development project through adding additional centers and employing some of the resource personnel as consultants to assist school districts as the need arises in implementing the new curriculum. Through the experience of working with the project staff and utilizing the resource personnel network, management has learned about the strategies, costs, and problems of providing inservice support to school districts and applied what they have learned in designing their inservice program for the new nationally developed curriculum that they will be publishing. And, many of the company's salesmen have learned how to use the resource personnel in supporting the initiation of change efforts in local school districts and taken to the role of coordinating follow-up support. Both of these activities involve substantial change in the salesman's traditional role from selling materials to acting more as a change agent. Since the schools do not pay for this assistance, the objective is still to sell materials but the relationship to school districts is far more supportive. If this company is successful in marketing fee-for-service support that they will be offering with their new nationally developed curriculum, then a further step will have been made toward development of greater integrative capability in this company.

INSTITUTIONAL CHANGES IN STATE ADOPTION BOARDS

The institutional changes in state adoption that we will mainly consider are in the organizational factors limiting the incorporation of innovations from the national curriculum projects rather than the level of innovation, since national curriculum development is unlikely to have caused much change in this latter area. Transition from the maintenance mode of continuing to administer existing policies and procedures to the developmental roles of leading curriculum change in a state, thoroughly evaluating curriculum alternatives, and providing staff assistance to school districts in implementing change would be the kinds of change that we do not expect have widely occurred. The organizational factors of primary concern are the policies limiting the number of curricula appearing on approved lists, the policies limiting approvals to only textbooks, and sampling procedures making the costs to publishers of submitting non-text book materials excessive, which were discussed in Chapter IV.

Limits on Number of Approvals

Analysis of changes in state adoption board policies regarding the number of alternatives on approved lists turned out to be more difficult than we expected primarily because the necessary historical data are difficult to obtain. Many state adoption boards were not readily able to reconstruct how many curriculum alternatives were approved in other than recent years. Part of the problem is that the number of alternatives approved is often not a matter of formal policy so that decisions must be reconstructed from data buried in the files. Also, the numbers of approvals often differ by subject area for a state and may change slightly from year-to-year.

Based on one comprehensive study of state adoption boards from the early 1900s through 1955 that we found and our interviews with publishers, there have apparently been two waves of change in the number of approvals on state adoption board lists. Beginning in the mid 1930s, through the mid 1950s, states gradually switched from single adoptions in each subject area by grade level to multiple adoptions of two or more curricula. Up to the mid 1930s, almost all states had single adoptions. By 1955, only California and Arizona had single adoptions and five states had combinations of single and multiple adoptions with usually multiple adoptions at the secondary level and single adoptions at the elementary level.[*] The author of the study from which those data were drawn attributes this wave of change to increasing recognition of the need for different textbooks to meet the different "levels of teacher and student readiness" and demands for a greater "voice in the selection of materials" as educators became more professional. Then, beginning in the mid 1960s a second wave of increases in the number of approvals in the multiple adoption states began to occur, extending into the 1970s. For example, in North Carolina adoptions went from two per subject area in 1960 to four in 1976, and in Tennessee from four in 1969 to 12 in the same period. But in this same period, Texas and Mississippi have not changed.[**] Because of its market size, California is the most significant example, which went from single adoption to listings of 14 in each subject area in 1972 in a major revision of the state's textbook laws. Comprehensive data on all states extending back to at least 1950 to actually determine that listings have been increasing faster since the introduction of new curricula than before does not exist, but publishers say that this is the case.

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[*] Joseph I. Hall, "A Study of the Development of Legislation Affecting the Selection of Textbooks in the United States," Ph.D. Dissertation, Harvard University, 1958, Table 21.

[**] Institute for Educational Development, "Selection of Educational Materials in the United States Public Schools," ED 044 030, 1969, Table 26;"Tennesses Official List of Textbooks with Wholesale Prices, Retail Prices, and Copyright Dates." State Textbooks Commission, 1975; "Current Adoption Textbooks, 1975-1976," Texas Education Agency, Bulletin 757, Austin, Texas, 1975; Textbook Purchasing Form, Mississippi State Textbook Purchasing

Increases in the number of state adoption listings since the introduction of the national curriculum projects are important for three main reasons. First, the larger number of alternatives reduces the influence of state adoption boards on product decisions made by publishers, as discussed in Chapter IV. Second, the larger number of alternatives reduces the advantage to publishers of simply being on an adoption list and the potential advantage to any publisher of attempting to politically influence the outcome of state adoption board decisions. Publishers d[illegible] that the amount of "skullduggery" in state adoption board decisionmaking has declined as the number of alternatives on the state lists has increased. Third, increases in the number of options on state adoption board lists which at least allows for a wider range of choices at the local level. The need to make these choices may also have effects on decisionmaking processes.

Non-Text Materials

As the data in Table 6.6 show, the policies of state adoption board have changes to the point where all but five of the total 22 adoption states will now approve enactive and other kinds of non-text materials, wheras prior to 1960, no state would approve non-text materials.

Board; and "North Carolina Textbooks," Division of Textbooks, Department of Public Education, 1975, Raleigh, North Carolina, 1975.

Table 6.6

CHANGE IN SAMPLING REQUIREMENTS FOR NON-TEXTBOOK ORIENTED PROGRAMS

State	No Change	Informal Relaxation	Formal Change
Arizona		X	
Arkansas	X[1]		
California			X
Florida		X	
Georgia	X		
Idaho			X
Indiana		X	
Louisiana		X[2]	
Nevada			X
New Mexico		X	
Oklahoma			
Oregon		X	
S. Carolina		X	
Tennessee			
Utah		X	
Virginia			X
W. Virginia			

SOURCE: Interviews with state adoption board administrators.

NOTES: [1] Only one textbook or full instructional program has been traditionally required for the review, thus there was little room for relocation.

[2] In the process of establishing specific guidelines.

Seventeen of these states had exclusionary policies written into the law or official regulations that only "textbooks" would be approved, while in the rest there was informal understanding that textbooks would not be approved. Of the 17 states that will now approve non-text materials, the law or official regulations have been changes in 12 and informally relaxed in the other five.

As indicated in Table 6.1, most of these changes occurred within the last five years, corresponding with the introduction of the NSF elementary science curricula. However, non-textbook basal curricula have to some extent, been available from publishers in other subject areas throughout the 1960s and especially in the 1970s so that the NSF curricula are only a contributing factor. Many state adoption board personnel mentioned that the Science Research Associates reading program, which contains a wide variety of materials packaged in modular forms, has been an important source of pressure for change. However, in Chapter V, many of the other non-text programs that publishers have introduced in recent years are attributable to the influence of national curriculum projects as shown in Chapter V for elementary science.

Sampling Procedures

Lastly, the procedures for providing samples and pilot testing of curricula have been revised to lower the costs to publishers in 15 of the 17 states where they have been changed to allow for approval of non-text materials. The changes have been formalized into new procedures in four of these 15 states and informally relaxed in the other eleven states. In most of these states, the change is that the state textbook administrator will negotiate a special arrangement with the publisher of a particularly complex program to reduce the costs of submission.

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STATE ADOPTION BOARD POLICIES REGARDING APPROVAL OF NON-TEXTBOOK MATERIALS

State	Year			
	Pre-1960	1960-1965	1965-1970	1970-1975
Alabama	T	T	T	T
Arizona	T	T	T	N
Arkansas	T	T	T	N
California	T	T	T	N
Florida	T	T	T	N
Georgia	T	T	N*	N
Idaho	T			
Indiana	T			
Kentucky	T	T	T	T
Louisiana	T			
Mississippi	T	T	T	T
Nevada	T	T	N	N
New Mexico	T	T	T	N
N. Carolina	T	T	T	T
Oklahoma	T			
Oregon	T	N	N	N
S. Carolina	T	N	N	N
Tennessee	T			
Texas	T	T	T	T
Utah	T	T	T	N
Virginia	T	T	T	N
W. Virginia	T			

SOURCES: Telephone interviews with state adoption board officials.

NOTES: "T" signifies policy restriction only to textbooks. "N" signifies policy allows for approval of non-textbook formats, including enactive materials, multi-media programs, and so forth. *Informal relaxation of state adoption board policies.

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Influence of National Curriculum Development

Based on our telephone interviews with state adoption board administrators and our site visits to the California and Florida boards, national curriculum projects have contributed to but not been the sole cause of these changes in state adoption boards. The influences of the NSF curriculum projects in stimulating the larger number of alternative products in the market and the introduction by publishers of products incorporating enactive materials were sources of pressure to increase the number of alternatives on state adoption lists and to modify policies and procedures to allow inclusion of non-textbook materials, but causal linkages to the changes that have occurred in individual states are difficult to show and there are other sources of pressure for change. We have already mentioned the non-textbook reading program published by SRA before any national curriculum development in reading had been supported, and there are probably many other examples of publisher initiated innocations that conflicted with state adoption board rules. In addition, sales of curricula incorporating A-V media have grown throughout the 1960s and 70s, partially due to funds available to local school districts directly from the federal government and bypassing state adoption boards through programs such as Title II (Library Resources) of the Elementary and Secondary Education Act (ESEA), similar titles in the National Defense Education Act of 1958, and Title I ESEA (Compensatory Education). Finally, there is the trend, growing especially in the 1970s to returning decisionmaking to authority to the local level.

The events leading to change in each state are different and not always traceable to one of these specific causes although the expansion in the number of curriculum alternatives and in non-textbook formats often appear to be underlying factors. One good example of a direct linkage is in Idaho where the state curriculum supervisoty staff, believing that the NSF elementary science curricula were far better than traditional programs, convinced the state adoption board not only to eliminate the exclusion on non-textbook materials but also to establish a policy of requiring school districts to either use one or more of the new science curricula or at a minimum some other "process-oriented" science program subject to state approval. At the other extreme, there is Florida where the state legislature rewrote the laws governing state adoption to eliminate corruption in the review process, provide for more direct local participation in decisionmaking and a wider range of choices, and to improve the quality of curriculum evaluations conducted. The education committee of the state Senate first became interested in the textbook adoption process when contacted by a local school district that an elementary mathematics curriculum that they had strongly recommended through existing procedures for local review had not been approved. The district charged that the board was disregarding the opinions of local school districts and upon investigation, the Senate committee found that the board was unable to produce a copy from its files of the district's review comments, indicating that these comments had not been taken seriously. The Senate's inquiry erupted into a political scandal of major proportions when further investigation produced evidence of serious conflicts of interest among board members. According to the director of the Senate committee staff, whom we interviewed, the ensuing political furor made possible a degree of reform that probably would have otherwise not been possible. But while key gaining political support for change, the legislature might not have undertaken their investigation and found the evidence of corruption if the local school district had not made their complaint in the first place. Thus, to understand all the causes of the change in the Florida state adoption board, we need to know why this school district voiced their displeasure to the state legislature, when they did rather than many years ago. How influenced were the teachers and other staff by the spreading of the idea that teachers should have more say in making decisions that affect them? Would the teachers have been as concerned about the textbooks they were using and would the alternative that they preferred have been available if the national curriculum development projects in mathematics had not been conducted? Answers to these questions become more difficult to find the more completely events are traced and the motivations of individual actors assessed.

In California, the record of events that led to a major reform of the state adoption process extends back to the early 1960s when a state legislator who was a former teacher first began to ask the state department of education questions about the state adoption board textbook approval process. According to the aide who did the staff work for the reform effort, this legislator could not see any good reason to perpetuate a system that kept the teachers out of the materials selection process, and limited the materials available to only hardbacked books and to a single title per subject.* In response to the legislator's questions the state department of education did a few short analyses of the adoption system but made no changes. In 1970, this legislator got a resolution passed to establish a Joint Committee on Textbooks and Curriculum to review and revise the state's textbook legislation. Without discussing all the details of the legislative strategy that was pursued, and political action, the central arguments in favor of opening up the adoption process that emerged from hearings and staff work were: (1) that the current system was not meeting the needs of students because the teachers would not select books that met their students needs and the reading levels of the state adopted texts were too high for some students; (2) that the system was unable to keep pace with "educational development" because of the restrictions on the numbers of approved textbooks, the exclusion of non-text materials, and the excessive time required for approval; and (3) that the system was expensive mainly because of inventory costs. In this list of arguments, the first concerns decentralization, the second the availability of a much broader range of instructional materials, and the third economic efficiency. According to the staff aide which of these arguments was more persuasive for which legislators is impossible to determine. Members concerned with finance and budget typically responded more to the economic arguments while members concerned with education typically responded more to the two needs arguments.

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*Conversation with Randall Young on March 5, 1976.

At a more theoretical level, what emerges from these cases and is reinforced by events in other states is that increased numbers of curriculum alternatives and additional curricula incorporating non-text materials stimulated by the national curriculum projects increased environmental pressures also stemming from other sources on the institution of state adoption to adapt their policies and procedures to new realities. In some states, the publishers of the NSF curricula actively worked for change and sometimes state supervisory staff promoted change to allow adoption of the new curricula, but these efforts were rarely pivotal in causing the changes that occurred.

Similarly, we did not find that broad support for returning control of materials selection to the local level was the dominant factor either.

Neither teachers not teacher's unions were typically very active in supporting change, nor were local school boards or parents. Furthermore, the textbook depositories in most states (most of which are privately owned) and in California the state printers were often sources of political resistance to change, counteracting any general sentiment to return power to the local level. Opening up the adoption process to a larger number of materials and non-text materials reduces the economic advantage to a state of maintaining a depository system or a state printer, since as the number of alternatives increases, possibilities of negotiating colume prices from publishers declines and inventory costs increase. Non-textbooks curricula lead to increased costs or necessity of bypassing the state depository if as in the case of the new elementary science curricula there are consumable materials.

INSTITUTIONAL CHANGE IN LOCAL SCHOOL DISTRICTS

Finally, we consider institutional changes at the local school district level in the two broad areas of incorporation of the developmental process and changes in organizational factors inhibiting incorporation of curriculum innovations. Although institutional changes at the local level are extremely important, we are severely hampered in conducting analyses by the unavailability of data. There is so little data that we cannot go much further than to hypothesize possible changes from out conceptual framework, as supported by fragmentary evidence from the interviews that we conducted and other data sources. We consider in turn local curriculum decisionmaking processes, materials development, inservice support capability, and some specific organizational factors limiting the incorporation of innovations from national curriculum projects.

Curriculum Decisionmaking Processes

Regarding curriculum decisionmaking processes in local school districts, we would ideally like to have longitudinal data on local school districts that would allow comparison overtime of their organizational processes for decisionmaking with usage of the new curricula. The most optimistic hypotheses would be that adoptions of the new curricula encourage adoption of many other curriculum alternatives; raise issues of educational gaols and performance that result in more extensive deliberation over goals, and more objective evaluation of alternatives; and raise issues of implementation that result in better coordination of decisionmaking on goals and provision of material resources. Not too surprisingly, we did not find any data sufficient to make such comparisons among school districts.

For school districts in general, several publishers whom we interviewed see a shift in decisionmaking processes from primary concern with goal-setting to concern for materials selection and tendencies to greater decentralization of authority for making selection decisions.

In the past, decisions regarding materials tended to be made by high level administrators without formal procedures and participation by district staff, teachers, and parents, and were generally not perceived to be curriculum decisions. Curriculum decisionmaking was generally perceived to be goal-setting and was performed through separate organizational processes. As has been noted in the research literature, this emphasis on goal-setting prior to the curriculum movement stemmed from the theoretical contributions of Franklin Bobbit and others beginning in the early 1900s.* They conceived of improving

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*Herbert M. Kliebard, "Systematic Curriculum Development, 1890-1950: An Interpretive Survey," paper presented for the NIE Conference on Curriculum Development, November 1976, pp. 21-31, and Elliot N. Eisner, "Franklin Bobbit and the Science of Curriculum Making," *School Review*, Vol. 77, No. 1, Spring 1967, pp. 29-47.

the school curriculum through identifying explicit educational goals in a Pscientific" manner so that teachers could proceed systematically in preparing and presenting lessons for students. These goals were to be derived from analysis of adult activities and skill needs.* Thus, Bobbit and the others who built on his work defined curriculum to be educational goals and specified a procedure for determining them. While such a contribution might not seem to be substantial in today's context, there had not previously been much effort to reform the school curriculum nor much thinking on methods for improving it. In practice, the theory came to be implemented either through school districts commissioning outside experts to conduct reviews and prepare goal statements or through the formation of committees of teachers and administrators who were charged with similar responsibilities. These committee structures became the standard approach to curriculum reform at the local level and were often institutionalized as the mechanism for dealing with local curriculum matters on a continuing basis. A practice evolved of issuing the goal statements produced as "curriculum guides" for teachers to use in their classrooms, further establishing the concept of curriculum being statements of goals. These committees were seldom specific on means of achieving these goals nor were they typically involved in materials selection processes. The guidelines rarely contained more than lists of available materials without assessments in relation to goals. It was assumed that teachers would be able to find means for achieving the goals stated in the guidelines, including the selection or preparation of appropriate materials.** This silence on materials continued into the 1950s, as indicated by the content of an authoritative book on local curriculum change published in 1957. In this book, which was written to describe methods that school districts had recently found for "wedding" curriculum planning (i.e., goal setting) and inservice teacher training, there is no discussion of materials assessment or selection processes, and in fact, barely any mention of either locally produced or commercial materials as a curriculum resource.*

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*Franklin Bobbit, "How to Make a Curriculum," Houghton Mifflin, Bostin, 1924, p. 8; and Herbert M. Kliebard, op. cit., pp. 31-44.

**Murray G. Phillips, "Learning Materials and Their Implementation," *Review of Educational Research,* Vol. 36, NO. 3, June 1966, p. 373; and William F. Laban, "Modern Trends in Science and Their Effects on Local Curriculum Development," *School Science and Mathematics,* Vol. 68, No. 2, 1968, pp. 141-144.

Since the 1950s, publishers' observations are that materials selection has become a more important curriculum decisionmaking process and the old guideline writing activity less important, although it has been replaced by efforts to select behavioral objectives. Furthermore, there has also been a trend toward broader participation and decentralization in materials selection processes. In effect, the meaning of curriculum has changes to include instructional materials. The indicators of these changes would be of increases in the proportions of staff time spent on materials selection, more highly formalized procedures for materials selection, broader participation of teachers and other staff in materials selection processes, and delegation of authority for materials selection to lower levels of organization. In all likelihood, curriculum supervisory staff are more directly involved in materials selection processes and spend more time on materials selection than in the past. Consistent with these changes, we expect that teacher's evaluation of instructional materials as an instructional resource has increased and their valuation of curriculum guides declined.

Although other reasons can be advanced for the occurrence of these changes in curriculum decisionmaking processes, we suggest that the new

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*Harold L. Spears, *Curriculum Planning Through Inservice Programs*, Prentice Hall, Englewood Cliffs, N.J., 1957, p. vii.

curricula and the subsequent expansion in materials have been a contributing maftor through making materials selection a more pressing, complex, and consequential decision than in the past and raising issues of allowing teachers to make different choices depending on their needs. The reasoning is simply that when few alternatives are available and the differences among many of them are small, or choices are largely predetermined, then making a decision is not seen to be important and demands for participation do not arise. Conversely, when the alternatives are more numerous and presented in concrete forms as they are when the choices are among different materials rather than goals, the importance of choosing among these alternatives is greater and demands for participation increase.

Whether goal-setting and materials selection are more closely integrated than in the past, and whether the quality of deliberation on goals and outcomes in decisionmaking has increased in unclear. Conceivably, the new curricula and other alternative materials have led to more deliberation on goals in the context of selecting materials because alternatives are presented in more concrete forms, but it is also possible that the only change has been in the structure of decisionmaking processes or that, in fact, deliberation on goals has declined in amount and quality. At least on paper, the goal oriented committee structures of earlier years offered the opportunity for participation by teachers and other school district personnel in debate on alternative instructional objectives, and it may be that the availability of a broader array of readimade materials has undercut this activity. Data from the 1975 survey of materials usage referenced earlier in this report are that 45 percent of the 12,000 responding teachers say that they have no role in the selection of the materials that they are using, while 30 percent say that they spend less than one hour per year and the remaining 25 percent say that they spend an average of 10 hours per year indicating that quality of deliberation in materials selection decisionmaking is low. Likewise, Schaffarzick found in his study of local curriculum change processes assessments of alternative materials were rarely conducted and, if they were, rarely consisted of more than "...hasty examinations...observations of use in a small sample of other schools (usually one other school), and informal conversations with users of the programs being considered."*

Neither the national curriculum projects nor the NSF have directed much support to institutionalizing developmental decisionmaking processes in local school districts. The materials development projects have been largely concerned with curriculum innovations and NSF's implementation effort with supporting usage of these innovations in the schools. Practically no effort has been directed to developing and supporting the incorporation of developmental approaches to curriculum decisionmaking. The major exception is the funding that NSF has provided for the FUSE network (Federaltion for Unified Science Education). FUSE involves both curriculum and curriculum decisionmaking process innovations. The curriculum innovation is that subject matter is organized into modular units each directed to a particular theme. These themes may be a scientific concept (e.g., equilibrium or energy), scientific processes (e.g., classifying or observing), natural phenomina (e.g., a river), or problems of science in society. Subject matter may be drawn from many different science disciplines in each unit. This allows for use of a wide variety of both commercial and locally developed materials in each unit and continuing change in both the themes that are covered and the materials used in each unit. Decisions on dropping themes and adding new ones are to be made jointly by the entire teaching staff in a continuing process. Through the network maintained by the FUSE center, different sites share techniques and procedures that they have found to be effective in making decisions, dealing with value issues, evaluating materials, and managing problems encountered in implementing an integrated science program. Several people involved in the network are now teaching the FUSE approach as a course in curriculum decisionmaking in their local universities. The other interdisciplinary NSF science curricula such as ISCS or Human Sciences are conducive to similar approaches, but implementation efforts have not emphasized the institutionalization of developmental decisionmaking processes.

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*Jon Schaffaczick, op. cit., p. 172.

Local Materials Development

The most optimistic hypotheses regarding the effects of national curriculum development on local curriculum development activities would be a higher level of materials development activity, incorporation of the trial-and-revision model of materials production, more frequent attempts to develop whole courses of study, greater use of resource personnel from outside the school district, and so forth. It would be particularly significant to know whether there are any differences in effects on local development activity among nationally developed curricula published in forms that discourage local redevelopment (e.g., textbooks and hihgly structured courses) as compared to nationally developed curricula that are more flexible and open-ended, such as the ESS elementary science program.

Since it is also conceivable that the availability of a much broader range of readimade materials has obviated needs for local development activity and we could not find any sufficiently comprehensive data, we will not even hazard a guess as to what the effects of national curriculum development have been on local development. It is probable that the most significant effects have occurred where implementation efforts have encouraged local development or among teachers participating in networks associated with national curriculum projects.

Inservice Support Capability

Assessment of possible effects of national curriculum development on the inservice support capability of local school districts is likewise impossible because of the lack of data, the complexities of distinguishing among inservice acitvities and the difficulty of sorting out other sources. Our impression from reading in the literature and interviews is that resource allocations to inservice training have increased but that progress toward integrating inservice training with goal-setting and materials selection has been slow. In a study of 17 large cities, one finding was that while primary influence in materials selection is at the building level in 12 of these school districts, only two delegate responsibility and allocate the resources for carrying out inservice programs to the building level.* The indicators would be declines in the amount of course-taking at universities and foreign trips as inservice activities and increases in workshops and other training activities that are integral to a specific change initiative. National curriculum development points up the need for inservice support of teachers, and the associated implementation activities provide models for school districts to follow and resource personnel.

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*I. Ezra Staples, "Impact of Decentralization of Curriculum: Selected Viewpoints," Association for Supervision and Curriculum Development, 1975, p. 22.

Organizational Factors

The only possible kind of change in organizational factors that we will mention is in physical facilities for science and capacity to provide material support for science curriculum activities. Although no longitudinal data could be found to make comparisons the kind of changes that would be relevant are increases in school district budgets for science equipment and materials other than textbooks, institutionalization of organizational capacity to supply material resources for science programs and the availability of more space for science activities. Such changes may be largest at the elementary level because of the introduction of enactive materials. School districts have undoubtedly adapted to the burdens of the new curricula in many different ways, ranging from no change to the example of the science center that has been established in the Fairfax County School District. This science center (which was initially organized by someone who participated in the ESS project) produces kits for the three NSF elementary science curricula and distributes them to teachers on demand. Much of the work is done by students and the center is now moving into supporting workshops for teachers, curriculum development activities, and after-hours science programs for students.

VII CONCLUSIONS

In this report, we have examined effects on education of NSF's national curriculum projects for the purpose of assessing implications for future federal policy in supporting national curriculum development. Because these projects introduced both the developmental process as a method of educational change and particular curriculum innovations as improvements in classroom learning, we have examined effects in both of these areas.

The basic premises of the study are that the school curriculum is influenced by a system of institutional processes spanning the education system in interaction with the social environment, and that these institutional processes are the proper basis for assessing the effects of national curriculum development. We called this system of institutional processes the curriculum policymaking system. Incorporation of innovations from national curriculum development in institutions other than the schools is important because of the influence of these institutions on the school curriculum. Incorporation of the developmental process is important because capacity to incorporate innovations from the national curriculum projects to generate new innovations without federal support is increased. The view is that the net effects of national curriculum development on the school curriculum are potentially greater than specifically attributable to direct usage in schools of the instuctional materials produced to the extent that innovations are incorporated in the school curriculum through indirect processes and that developmental capacity of the curriculum policymaking system increases.

Nationalizing Influences of the Curriculum Policymaking System

Available evidence indicates that prior to the NSF curriculum projects the school curriculum was highly uniform from school to school and had not changed much over the years in the structure of subject matter taught and modes of children's interaction with subject matter, which were defined as the two main components of the school curriculum. The evidence for uniformity in subject matter is that prior to the national curriculum projects, single textbooks typically had more than half of total sales in individual subject areas of the school curriculum (e.g., Grade 10 Biology) and that competing textbooks tended to have similar subject matter content. The evidence for stability in subject matter is that companies were typically able to hold their market shares for many years and that changes from edition-to-edition were typically only a few percent of the total word-space in a text. The content of textbooks was taken as a valid indicator of the school curriculum because of the correlation between the content of materials and subject matter covered in the classroom, as shown by evaluations of effects on student achievement of the new curricula and student recall of topics studied in relation to the content of materials used. Subject matter was also uniform in that students were mainly expected to recall facts from subject matter rather than to learn concepts and develop thinking skills, as shown by classroom observation data. Regarding modes of interaction with subject matter, students in the preponderance of schools learned almost exclusively from textbooks rather than from visual media or through direct manipulation of materials representing real subject matter phenomena in the classroom. Classroom observation data also reveal that the predominant mode of classroom interaction was a teacher in front of a whole class with the students listening to subject matter presented verbally, responding to short answer questions, and reciting from text materials when called upon. In short, the school curriculum was uniform in the subject matter covered and teacher-centered with students having a passive role in the learning process. In effect, there was a national curriculum eventhough the federal government has never had any power to determine the school curriculum

The national curriculum existed despite the absence of any scientific knowledge that there was one best form of education for the needs of all children and society. Furthermore, substantially different forms of curriculum are possible, as indicated by the diversity in schooling that existed, the progressive model of education that was successfully demonstrated in the Deweyian experimental schools, and the innovations from the national curriculum projects, as well as many other ways. Thus, alternatives to the national curriculum exist but are not reflected in marked diversity of the school curriculum. Stability in the school curriculum can possibly be explained as a natural tendency of complex social organizations like schools but not the uniformity in the school curriculum if schools are autonomous organizations, unless the preferences of communities are equally similar and communities control schools. These discrepancies raise the question of why the school curriculum exhibited so much uniformity and stability at the time of the first NSF national curriculum projects.

We hypothesize that much of the uniformity and stability in the school curriculum is due to influences of the institutional processes in the curriculum policymaking system. We examined two of these institutional processes in some detail: El-hi publishing, and state textbook adoption. Because many other institutional processes in the curriculum policymaking system had to be excluded, such as teacher training in schools of education, standardized testing and school accreditation, our description of the influences is partial. Our research could be expanded to include these other institutions in the curriculum policymaking system.

One major influence on the school curriculum is the non-developmental character of curriculum decisionmaking processes interacting with the dependence of teachers on commercially produced materials. One factor is a tendency in curriculum decisionmaking to go with the most popularly used instructional materials rather than to undertake independent assessments of goals and needs, and thorough evaluation of alternatives in relation to needs. As a result, there are tendencies for the successful curricula in the market to become more successful, making it difficult for publishers to enter curriculum markets with substantial alternatives. A second factor is the many loci of centralized decisionmaking in the curriculum policymaking system. These include several state textbook adoption boards and similar structures in many local districts that restrict alternatives available to teachers and in extreme cases impose choices on them. This centralization is advantageous to publishers already having successful products and results in decisions satisfactory to median needs, which inhibit investment by publishers in susbtantial alternatives to the predominantly used curricula. A third factor is the dependence of teachers on instructional materials. The evidence is that teachers rate commercial materials to be their most valuable curriculum resource, that over 90 percent of classroom time is organized around materials, most of which are commercially produced, and that learning outcomes reflect the content of materials, as we discussed above. Furthermore, leading commercial materials are often used as references in both state and local curriculum guideline writing activities and as course material in schools of education. Finally, a fourth factor is that usage of particular materials may over a period of time influence teacher's competencies and preferences regarding subject matter and instructional methods, causing them to feel "uncomfortable" with major alternatives. While not quantifiable nor deterministically linked, these factors form an array of incentives tending to produce convergence to uniformity in the school curriculum.

A second major influence of the curriculum policymaking system was interaction of the costs of curriculum development, the fragmentation of the school curriculum into many subject areas and the small proportions of school district budgets allocated to the purchase of materials. The interaction was that while the development of major curriculum was found to cost in the neighborhood of several hundred thousand dollars per year, revenues in different subject areas were essentially fixed by the proportion of school district budgets spent on materials, total student enrollments, and traditional allocations of student time to different subject areas by grade level. These allocations were institutionalized at the school level in departmental structures, teacher staff sizes and competencies, graduation requirements, and so forth. As a result we found that only publishers having large market shares earned the revenues required to invest in the development of major curriculum alternatives. However, market incentives did not favor these publishers abandoning their successful products for investment in the development of major alternatives but rather to invest available funds in product improvements, broadening the appeal of these products in the market. Smaller publishers have greater incentive to attempt breaking into the market with major alternatives to established curricula but not the financial resources to invest in the necessary product development, and are less able to invest in the options and refinements in that leading publishers can afford to invest in. These options and refinements provide additional advantaged in the market to leading publishers.

A third influence on the school curriculum was institutionalized organizational structures and policies inhibiting certain kinds of curriculum innovations. The two most significant kinds of inhibiting structures that we considered were the factors limiting curricula based on enactive materials, and the factors limiting the reorganization of subject areas. The important property of these structures is that while not intrinsically significant for educational outcomes, they inhibit changes at the classroom level that are potentially very educationally significant. Rearrangement of subject areas is needed from some approaches to making the school curriculum follow from problems that are meaningful to students or that may be socially important rather than from the principles of the scientific disciplines. Enactive materials allow concrete manipulation of real phenomenon in the classroom which may be far more consistent with the way children learn than traditional modes of instruction. The structures outside the classroom inhibiting rearrangement of subject matter were the discipline orientation of teacher training, school teaching staffs, testing, college entrance requirements, and so forth. The structures outside the classroom inhibiting the introduction of enactive materials were the exclusionary policies of state adoption boards, the lack of organizational capacity in publishing, and the lack of support capability in local school districts, as reinforced by the tradition that textbooks and schools go together. The importance of these structures is that, while remote from classroom activities, they span several formal institutions in the education system with no particular organization within these institutions having much incentive to change unless the restricted innovation is widely incorporated in the school curriculum.

The fourth major influence on the school curriculum is what we called the lack of integrative capability in the curriculum policymaking system. Publishers, as the major source of curriculum materials (and probably curriculum innovations), did not have any capability beyond brief workshops by outside consultants to assist schools and teachers in making change. And, while available data are insufficient to comprehensively describe inservice training activities in local school districts, there are indications of weakness in that decisionmaking on materials selection and inservice training were administratively separate and that inservice training activities were generally not related to specific curriculum change initiatives (typical inservice activities were taking a university course, lectures by visiting professors, foreign trips, etc). Lacking this integrative capability, publishers had little incentive to invest in the development of major alternatives to the dominant forms of school curriculum and school districts typically did not have the organizational capacity to undertake their own change initiatives.

There are two notable properties of these institutional influences on the school curriculum. The first is that each "influence" involves a multiplicity of policies, organizational capabilities or structures, and interinstitutional interactions. No single element in any one institution is controlling. The elements are mutually reinforcing and span the formal boundaries of institutions. Furthermore, no organization in one institution has any authority to command or even the capability to strongly influence change in any other institutions. No single point of entry for intervening with federal support for organizational change to diminish an influence is obvious.

The second is that except for schools, the institutions involved are completely outside the organizational channels of the major federal education programs from the U.S. Office of Education through the state departments of education to the schools. Publishers are a private institution as is the testing industry, school accreditation agencies, and even some schools of edcuation. State adoption boards are public institutions but largely independent of state education agencies and the direct influence of federal programs. There are also many professional associations and private interest groups in the matrix of curriculum policymaking institutions. Yet, the functions of these institutions concern the formal, technical core of the schooling process. The major federal programs bypass the curriculum policymaking system because they are mainly intended to achieve educational equity through intervention at points of financial leverage on the educational system.

EFFECTS OF NATIONAL CURRICULUM PROJECTS

In contrast, the national curriculum development activities of the National Science Foundation concerned the core of the school curriculum and directly engaged institutions in the curriculum policymaking system.

The curriculum innovations advanced by NSF's national curriculum projects proposed substantial changes in the subject matter and the modes of interaction with subject matter in the school curriculum. For the projects in the natural sciences, we summarized these innovations as intended to make subject matter more relevant to students' needs and the public interest and to shift from passive modes of learning to active construction. Specific innovations for making subject matter more relevant included replacing out-dated subject matter in the school curriculum with modern scientific knowledge; shifting subject matter away from facts to unifying concepts in order to make the value of studies both more intrinsically meaningful to students and longer lasting; organizing subject matter around problems found to be important to students at different stages in their personal development. The innocations intended to shift learning towards active construction of knowledge generally involved presenting subject matter in ways to facilitate learning how to ask questions of phenomena and other thinking skills. At the elementary level, one innovation was to present subject matter in the form of concrete materials to enable learning through direct manipulation of natural phenomena. At the intermediate level, an innocation was to modularize activities in ways increasing the level of social interaction among students. At the high school level, there was the innovation of the "narrative of inquiry."

Viewed together in grade sequence, the innovations from the NSF science curriculum projects intended to shift learning to active construction represent a potentially fundamental change in the school curriculum, as indicated by the obvious consistency with Piaget's theories of cognitive development that achievement of concrete operational virtuosity at early ages is a precondition to attainment of formal thinking in adolescence and that development occurs through personal interaction with the physical and social environment. We reviewed evaluative studies showing that the elementary science curricula have significant effects on acquisition of reading and language skills and recent research findings tie poor reading skills to inadequacies in the information processing abilities of children rather than in the perceptual, verbal, or linguistic areas. Yet, reading is typically taught through symbol recognition, word association, and linguistic methods. It may be that more inquiry-oriented science in the school curriculum would be a great and in improving reading skills, not to speak of the underlying gains in thinking ability that are presumably of even more general benefit. Furthermore, gains in thinking ability at higher levels of cognitive and social development may be contingent on early and continued opportunities through all successive grade levels to learn through active construction. Thus, incorporation of innovations supporting active construction at one grade level or another may not produce much effect. Active construction may have to be imbedded in the school curriculum through all grade levels to be effective. This fundamental potentiality (and source of difficulty) in the NSF science curriculum projects of shifting to active construction becomes apparent only when all of the projects are considered together as an attempt to reform the school science curriculum from grades K through 12, and when the focus is on the innovations produced rather than the materials produced in particular subject areas and specific grade level. The implication for policy is that the primary criterion for undertaking national curriculum development is the expected effects on the cognitive and social development of children from restructuring subject matter and the mode of interaction with it in the school curriculum according to the kinds of innovations proposed. The criterion applies mainly to the need for national development rather than specific projects since there may be many different kinds of innovations for achieving the desired restructuring of subject matter and modes of interacting with it, not likely to all emerge from one project nor to be feasible to incorporate in it. Furthermore, support of several projects rather than a single one allows for differing value perspectives to diffuse the federal control of education issue. The restructuring may de desired to increase achievement of traditional educational objectives or to introduce new educational objectives. We have argued in this report that the NSF science curriculum projects were primarily intended to introduce new educational objectives. The sources of need for restructuring may be new social conditions or advances in scientific knowledge of subject matter or pedagogy. Any judgments will involve value conflicts and great uncertainty about eventual outcomes.

A corollary of this criterion is that national development should not be undertaken unless desired restructuring is unlikely to occur through the normal functioning of the curriculum policymaking system because of institutional factors inhibiting the generation of the necessary curriculum resources and incorporation in the school curriculum.

How effective national curriculum development can be in achieving desired effects on the school curriculum can only be determined through empirical analysis of past efforts. Because of the magnitude of the task, and the lack of available data, we limited analysis to the science projects and mainly to BSCS. The data pertaining to BSCS were presented in several places throughout this report. Textbook sales data show that classroom usage of the BSCS textbooks grew steadily from 1963, when first commercially released, to approximately 50 percent of enrolled students in 1970 and then declined to a current level of about 30 percent. That these new materials have actually affected classroom practices as indicated by our synthesis of available evaluation research studies which show that the learning outcomes change in the direction of BSCS objectives and one study which shows that student recall of subject matter covered correlates with the subject matter in the texts that they used. The only study of actual classroom configurations of the innovations in BSCS that we found concludes that in the six classtooms studies, there was considerable variation in the way that biological concepts were presented. But this study did not consider that the teachers involved may have increased the emphasis in their classroom on concepts since using the BSCS materials. From our interviews with project developers and the general literature, the classrooms where BSCS materials are used most certainly have not been revolutionized in the sense that a majority of the teachers have fully incorporated BSCS innovations. More probably, the majority of teachers using BSCS materials have only made some changes consistent with BSCS innovations. We suspect that changes in subject matter have been larger than changes in teaching methods. But the widespread use of BSCS materials, the substantially different sturcture of their subject matter content, and the evidence of effects on learning outcomes, lead us to conclude that a significant fraction of 10th Grade biology classrooms are measurably different than prior to BSCS. In a special analysis, we also showed that at least 15 percent of the 10 grade biology textbook that had about 80 percent share of the market prior to BSCS has been changed to incorporate BSCS innovations. If we had included paragraphs that were partially rewritten, this 15 percent figure would have been higher; however, the fact remains that this textbook retains content wmphasis that is had prior to BSCS. This textbook is now used in about 30 percent of classes for a total of about 60 percent of all biology classes including those using the three BSCS versions. No attempt was made to assess incorporation of BSCS innovations in the other 10th grade biology texts, except that nearly all texts now deal explicitly with the biological concept of evolution for the first time. In summary, we found that the 10th grade biology curriculum has changed in the directions advocated by BSCS and is more diverse than in the past. Since other researchers have found similar effects on publishers' textbooks in other high school subject areas where NSF projects were supported, we conclude that the science curriculum development projects have in general diversified the school science curriculum in the directions intended. Paradoxically, national curriculum development has tended to ne-nationalize the school curriculum.

Importantly, the proportion of incorporation of BSCS innovations that has occurred through direct adoption of the materials produced is apparently about the same order of magnitude as the incorporation that has occurred through adoption of other materials since the market shares of the BSCS materials and the leading publishers' materials, which partially reflect the BSCS innovations, are about the same.

At the elementary level, we showed that the enactive materials innovation has been incorporated to varying degrees in   percent of all publishers programs as compared to none prior to the NSF science projects. Data for 1972 show that the new NSF curricula were being used in some form by about 10 percent of teachers, which was less than five years after the initial commercial release of two of the three NSF programs. In the last five years, total sales of elementary science curriculum materials have increased relative to other subject areas indicating that the NSF projects have made elementary science a more important subject in the elementary school curriculum, although not by a great deal. The enactive materials that have been purchased represent some change in the elementary school curriculum toward active construction, but to what extent to unclear because of the fundamental changes in teacher behavior required. Correlational studies tend to show that teacher use of the new science curricula as opposed to textbook programs is strongly correlated with more active student participation in the learning process.

Other possible effects of the innovations from the national curriculum projects that we did not examine include incorporation in the standardized tests of the College Entrance Examination Board and other testing organizations, in subject matter and methods courses taken by pre-service teachers, in state curriculum guidelines, and so forth. Also, we did not make any attempt to assess incorporation of innovations from the national curriculum projects in laboratory facilities and activities.

We stress that these findings of change in the 10th grade biology curriculum are primarily dependent on evaluative research studies of moderate quality in their research designs. We rejected studies that failed to meet certain minimum criteria but had to make these criteria less stringent than we desired in order to have a large enough sample of studies to synthesize. In particular, no studies had random assignment of both teachers and students. We accepted the deficiencies in research design and presumed that if students using BSCS materials perform better on tests sensitive to BSCS objectives, than students using conventional materials then the curriculum experienced by the BSCS students is different than the curriculum experienced by the other students.

Exactly which BSCS innovations account for the difference and how significant the differences would appear to a classroom observer, we cannot say.

There also has been some incorporation of the developmental process in the curriculum policymaking system and changes in institutional factors inhibiting the incorporation of particular curriculum innovations. In publishing, we found that national curriculum development has affected market conditions in ways that have encouraged firms to introduce new products in competition with the previously dominant materials. Enough of these firms have been successful that the shares of the market held by the leading firms have dropped substantially. Thus, more product alternatives are available now than before national curriculum development and more firms have substantial funds to invest in new proudcts. Here the new selection environment created by the introduction of the new curricula has reduced the advantage that leading produces used to have in the market simply by cirtue of success. But progress toward full incorporation of the trial and revision cycle of product development has been slow, because the market advantage from having a fully developed product is still small, and because the limits on revenues due to market fragmentation and low school expenditures on materials have not been affected. The new selection environment created by the introduction of the nationally developed curricula in concert with the increased number of alternatives from publishers has also led to state adoption boards increasing the number of approved alternatives that they will approve. Similarly, the inclusion of enactive materials in many of the new curricula has added to environmental pressures that have led state adoption boards to remove restrictions that only textbooks will be approved and to modify sampling procedures to reduce the costs to publishers of approval. There is some evidence that the new selection environment has also caused some decentralization of decisionmaking in local school districts and more attention to materials selection as an important aspect of curriculum decisionmaking. In short, the primary institutional effect of national curriculum development has been on curriculum decisionmaking processes, which have been adapted in response to the new materials selection environment in ways that facilitate greater diversity in the school curriculum, including incorporation of the enactive materials innovation. The significance of these changes is that the byproduct effects of national development on the environment in which decisions are made may provide greater leverage on decisionmaking processes in the curriculum policymaking system than any form of direct intervention.

Available data indicate that these effects on the school curriculum and the curriculum policymaking system are strongly dependent on federal funding for school-level implementation activities, primarily through increasing adoptions of the nationally developed materials. For curriculum-specific implementation activities the data generally show an increase in adoptions of a third or more. Resource personnel training in one elementary science project may have increased adoptions by an order of magnitude. But our findings only applied to effects at the margin, since there was no way to determine how much lower adoptions would have been without any NSF support for curriculum specific activities. For the subject matter oriented training activities on which over 90 percent of NSF's funding for implementation were spent, the evidence was that usage of BSCS materials continued to increase as long as implementation funds were available but afterwards fell by nearly a factor of two, and that usage of the new curricula at the elementary and high school levels roughly corresponds with the protion of teachers at these grade levels who have participated in some training activity. The figrues are respectively about 15 and 50 percent of teachers for both usage and training. Although not definitive, these data come closer to measuring the full impact of NSF's implementation activities than the results for the curriculum specific training. The indication is that most of the adoptions of the new curricula are due to federal implementation funding. We caution that these results are tentative because of data inadequacies.

These results are only for adoptions and do not in any way indicate whether NSF's training activities have any effects on the level of incorporation. The effects on incorporation may be significant but available data are insufficient to draw any conclusions. Research is needed to isolate the effects of implementation support from the adoption of materials. Our study found no significant difference in the rejection rate for the new elementary science curricula among teachers who had and had not attended an NSF training program.

The implications of these findings regarding adoptions are basic for federal policy in supporting curriculum development. The first implication is that development should be carried beyond the production of typological to at least semi-finished materials even if federal implementation funds are provided. The second is that development should not be undertaken unless substantial funds are available for implementation.

If national development is only carried through the production of prototypical units, then development would either have to be completed by school districts or publishers, since we found that the recommendations of blue ribbon curriculum committees, which amount to typological curricula, have not in past been incorporated in the school curriculum to a significant extent. Since the vast majority of local school districts do not have the capacity to undertake major curriculum developments, incorporation of innovations in typological curricula is likely to be even more dependent on federal funds than adoptions of the finished materials have been and to require a much higher-level of funding than when the materials are centrally developed to achieve comparable results. Since publishers cannot generate sufficient revenues to support extensive implementation activities at the current level of development of the curriculum policymaking system, they would either have to incorporate such minimal forms of the innovations in the typological curricula that the resulting materials could be successfully sold in conventional ways or be reliant on federal funding of implementation activities. In the former case, development costs would be less but so would the effects on the school curriculum. In the later case, development costs would be lower to the government but not less overall unless publishers are substantially more efficient developers of highly innovative curricula. There may be circumstances where development only through typological curricula can be effective (a case was footnoted in Chapter II), but not in general as the final product of national curriculum development.

Regarding the second implication that development should not be undertaken unless federal funds are available for implementation, the reasoning is that for the BSCS project we found that direct use of BSCS produced materials accounts for a major proportion of the incorporation of BSCS innovations attributable to materials usage. Therefore, incorporation of BSCS innovations would have been commensurately less if NSF had not provided funds for implementation. Furthermore, the incentives for other publishers to incorporate BSCS innocations in their materials would have been less if the BSCS materials had not been successful in the market, and the leading publisher probably would have been able to retain its dominant share of the market. Also, it is likely that any incorporation of BSCS innovations in testing, schools of education, and so forth has followed from rather than led incorporation in the school curriculum.

We stress the weakness of the data base supporting this finding concerning the importance of federally funded implementation activities to national development. We have accepted correlations as evidence of causality in some of the data and our analysis mainly concerns only one NSF project. The SMSG (new mathematics) national curriculum project is an important counter-example, since practically no funds were provided for implementation at the elementary level and there are indications of substantial change in the school curriculum. SMSG materials were released to the public domain. But SMSG followed a strategy of working through the social network in school mathematics to create demand for the new materials and the intense social climate of the early 1960s was extremely favorable to change. We chose not to analyze the national curriculum projects in mathematics in detail in this report. Because of the cost and policy implications of our conclusions, more research is needed.

In particular, more research is needed on the incorporation effects of different school level implementation strategies. NSF mainly supported subject matter oriented teacher institutes, but also resource personnel training activities, university based workshops in specific curricula, awareness workshops, and other activities. Other alternatives are teacher networks, regional resource centers, and strategies combining the old concept of curriculum committes with local materials development and integrated support for teachers. The important issues are to understand if there are any strategies that result in greater incorporation of innovations from national curriculum development, in what situations in local school districts, and at what cost. The data in this report suggest that awareness activities may not be worth their cost since adoptions are so highly localized (at least in the early stages of adoption) and because of publisher's sales forces. Other data suggest that resource personnel training may be the most advantageous now. The instances were the high correlation of resource personnel with adoptions in the elementary science project examined, the effects of the trial centers, and the example of a science center that has been established in a local school district by a former participant in one of the national projects. Findings that resource personnel lead to more change for less cost could have the important implication for policy that national curriculum projects should involve larger numbers of school personnel than in the past in materials development, trial centers, and workshops conducted in conjunction with development activities. These personnel would be considered as important a product of development as the innovations and materials produced. National projects would be conducted as large temporary organizations created for producing all the resources needed for curriculum change. The concepts and instrumentation for conducting this research is becoming available.

Incorporation of innovations from the national curriculum development in institutions other than the schools and implementation strategies is another important area for research. These institutions include schools of education, the testing industry, teacher certification and so forth. NSF has supported improvement efforts in schools of education and co-sponsored commission on teacher certification. The effects of these efforts need to be examined because of the possibly important implications for implementation policy.

Possibilities of supporting the incorporation of the development process and innovations from national curriculum development in institutions other than the schools might lead to more comprehensive and in the long run more effective curriculum reform strategies than in the past. Instead of mainly being limited to national development and school level implementation, reform efforts could be intended to more directly involve other institutions in the curriculum policymaking system. More effort than in the past could be devoted to test development either by the established firms or independently. Development projects could have activities to work with a number of schools of education in the development of new course materials, teacher training programs, and in building resource centers to work with local school districts. Programs could be established in universities for training professional staff for publishers. Professional teachers organizations might be given greater responsibilities. A "policy system" instead of a "school level" implementation strategy could emerge.

One of the reasons for raising the possibility of a "policy system" implementation strategy is the long time required after the initiation of national development for changes to occur in the school curriculum and the curriculum policymaking system. In general, the NSF projects have taken about five years to produce finished materials and then adoptions extend over many more years. The usage peak for BSCS materials was not reached until seven years after the materials were initially released. Then, curriculum markets were affected and publishers began to introduce many new alternatives which changes the selection environment in curriculum decisionmaking, which led to changes in decisionmaking processes, and so forth. Carefully considered implementation activities in other institutions than the schools, might reduce some of these lags in implementation.

The slow response time of the curriculum policymaking system to national development also carries an implication that national development should be limited to basic curriculum problems and not employed as a means of facilitating educational response to transient and possibly surface social problems, or social problems for which existing response mechanisms in the curriculum policymaking system are likely to be adequate. We have seen that the danger in undertaking national development to improve the quality of scientific manpower to win the Cold War with the Soviet Union was no longer the critical problem by the time students affected began to reach the work force. The danger is that the social environment will so shape the national development effort that the solutions produced will turn out to be for problems that no longer exist when results begin to affect the school curriculum. Sorting out surface from underlying curriculum problems is no mean task, but focusing on the cognitive and social developmental needs of children in relation to the basic structure of the school curriculum is a starting point.

Policy for national curriculum development is important to consider because of the potential for low cost. We estimated that the cost to the government for the BSCS project and the associated implementation activities has been less than 50 cents per student reached for development and 50 cents for implementation. These figures are based only on direct usage of BSCS materials. These figures would be lower if there was some way of accounting for influences on other materials, teacher education, and so forth. Importantly, these figures are low only because BSCS materials found great success in the schools. The corresponding cost figures for TMMW, another national project may be in the area of several hundred dollars per student because of the implementation difficulties encountered. The possibility of low costs exists because instructional materials are a natural point of entry into the curriculum policymaking system.

The policy challenge is to find ways of achieving the full educational potential represented in the materials in the schools.

Appendix A

ESTIMATION OF STUDENT USAGE OF THE *MODERN BIOLOGY* AND BSCS CURRICULUM PRODUCTS

The estimates of student usage for the *Modern Biology* and BSCS curricula presented in Fig. __ were obtained from data on unit sales of textbooks supplied by Holt, Rinehart, and Winston, and BSCS, Inc., using survey data on actual student usage of the BSCS versions in 1970.* Our estimates are less accurate than survey data, but these are not available.

Estimation of student usage from textbook sales would be relatively simple if all schools gave students personal copies of the textbooks that they use. Then total student usage across the country of a particular textbook in a given year would simply be the sum of total unit sales of that textbook in that year, with allowances for losses in the distribution system. While some schools allow students to keep their textbooks or require that they be purchased, most do not. Instead, the textbooks used by students are collected or bought back at the end of a course, and issued again in the following year. Thus, each textbook sold by a publisher may be used by several students before it is discarded.

We account for these practices in our estimation procedure by expressing the usage lifetime of a textbook in the form of a probability, P(y), that a textbook sold in year zero is still being used by a student "y" years later. Then the estimated student usage in year "y" is the sum over all previous years of the textbooks sold in each previous year times the probability that a textbook sold in that year is still being used. In equation form, our estimate of student usage is:

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*Fred Schlessinger, op cit., pp. 64-68.

$$s(y) = \sum_{i=0}^{y} \delta \cdot p\,(y-i)\ t(i)$$

where t(i) is unit textbook sales in year "i" and "s" is the fraction of textbooks sold that reach students.

The functional form of p(y) was determined through an inference procedure using actual data on student usege in 1970 that is available. The procedure was to try different mathematical forms for the probability p(y) to find the function and the values of its parameters that minimized the square of the error between estimated student usage in 1970 of each of the three BSCS versions and the survey data. The mathematical functions that we tried all model the probable lifetime of a textbook as a montonically declining function from "1" in the initial year year of sale to a value of "0" as use increases. These functions were:

$$p(y) = \begin{cases} 1 & 0 \le y \le \\ 0 & \alpha \le \end{cases}$$

$$p(y) = \begin{cases} 1 & 0 \le y \le \alpha \\ \dfrac{-\,y}{-\,d} & \alpha < y \le \beta \\ 0 & \beta < y \end{cases}$$

$$p(y) = 1/[1 + \alpha \exp\,(\beta y)] \qquad y \ge 0$$

$$p(y) = 1/[1 + (y/\beta)^{\alpha}] \qquad y \ge 0$$

Optimization was done manually by calculating the squared error for each function and wide range of values for α and for each of these functional forms. The function and vales of its parameters that resulted in the minimum squared error of estimated to actual usage of each of the three BSCS versions was chosen as the optimum mathematical expression for the probable lifetime of a textbook, which we will call $p^{*}(y, \alpha^{*}, \beta^{*})$.

This optimum expression was then used to estimate student usage of *Modern Biology* and the BSCS versions over the years according to the basic equation for converting sales data for each text into student usage estimates:

$$s^{*}(y) = \sum_{i=0}^{y} p^{*}(y-i;\ \alpha^{*}, \beta^{*})\ t(i).$$

Neither the optimum mathematical expression that we found for the lifetime of a textbook nor the sales data that were obtained from Holt, Rinehart, and Winston and BSCS, Inc., to calculate the usage estimates can be presented in this report. Publichers consider sales information to be confidential and we agreed not to publish either the original data nor any information sufficient to allow inference of it from the student usage estimates. All that can be reported is that the last of the four functions listed above was found to result in the minimum error and with values of α and β such that the average lifetime of a textbook was found to be 3.5 years. This result is close to standards in the industry for binding textbooks to have them last for five years. In finding this optimum, we first assumed $\delta = .95$ (signifying that five percent of textbooks sold do not reach students) and then checked at the optimum that this was in fact the value that produced the minimum error in our estimates and it did.

In finding the optimum mathematical expression for textbook lifetime, we used data on student enrollments in courses using the BSCS versions from a nationwide survey conducted in 1970 by the Center for Science, Mathematics and Environmental Education at Ohio State University. The only alternative data source that we could find is a survey published by the National Center for Educational Statistics that contains BSCS enrollment data for 1972. These data show substantially lower enrollments than in the survey that we used but have been questioned by some analysts because of the way in which the survey questionnaire was formatted.* We estimate student usage using this data and found that the optimum mathematical function for textbook lifetime resulted in an average lifetime of 1.9 years, which is substantially lower than publishers believe to be the case. Therefore, we chose to estimate student usage using the data from the Center for Science, Mathematics, and Environmental Education. The errors between estimated student usage using this data and the actual data are shown in Table A.1.

Table A.1

DIFFERENCE BETWEEN ESTIMATED AND ACTUAL STUDENT
USAGE OF BSCS TEXTS IN 1970
(thousands)

BSCS Version	Estimated	Survey data	Difference
Green	507	479	16
Yellow	478	475	83
Blue	285	338	53

The major assumption in this method of estimating student usage is stability in the lifetime of a textbook, or, in other words, that the function $p(y, \alpha, \beta)$ does not change over time. This assumption is probably most in error in the early uears after the initial release of BSCS. One possibility is that many schools rushed to replace the biology texts that they were using before they normally would have been discarded. To this extent, actual student usage of *Modern Biology* probably declined more rapidly than shown in Fig. __. Another possibility is that many of texts bought by schools in these early years did not reach students because teachers preferred to continue using the texts with which they were familiar and left the BSCS texts purchased on the shelf. To this extent, actual student usage of the BSCS versions was lower in the early years than shown in Fig. __. BSCS staff believe that this situation was far more prevalent than the former. If true, then student usage of BSCS increased more steadily than shown in Fig. __ to the peak around 1970 when the actual data are available.

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*Private conversation with Fletcher Watson of Harvard University.

Another major assumption is that the probable lifetimes of BSCS and *Modern Biology* textbooks are the same. If *Modern Biology* textbooks tend to remain in use for a longer time period than BSCS textbooks, then our estimates of *Modern Biology* usage are low. Conversely, if *Modern Biology* textbooks tend to remain in usage for a shorter period of time, then our estimates of BSCS usage are high. Since textbook purchase is basically dirven by budget allocations in states and local school districts, and these allocations are geared to four-to-five year purchase cycles, the likelihood that there are significant differences in usage lifetimes among *Modern Biology* and the BSCS versions is low.

Data from other sources support our results. First, we calculate a market share of 80 percent to *Modern Biology* in the early 1960s, which is consistent with common knowledge in the publishing industry that the text had this large share of the market. Second, student usage figures for different texts that we estimate for 1975 are consistent with the data on teacher usage of materials reported in Chapter II.* From this data, 31 percent of all teachers reporting usage of one or more biology texts reported using *Modern Biology* as compared to estimated student usage of 25 percent. Comparable figures for the BSCS Green, Yellow, and Blue are respectively 9.5 percent as compared to 6.8 percent, 6.3 percent as compared to 6.2 percent, and 5.6 percent as compared to 4.4 percent. Our percentages of estimated student usage would be higher if total enrollment in high school enrollment in biology was lower than projected in Fig. __, while the percentages of reported teacher usage overestimates student usage to the extent that teachers use different texts in different classes that they teach or use multiple texts in some classes. These other data indicate that our estimates of student usage are consistent with data from other sources at the extremes of 1962 and 1975 eventhough we only used data on acutal usage for 1970.

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*P. Kenneth Komoski, op cit.

Appendix A

THE INSTRUMENT FOR CODING EMPHASIS AND THEMES

The following instrument entitled "Instructions for Coding" is a category scheme for determining the level of biological emphasis and the themes reflected in the subsections of any biology textbook.

A reliability trial of intercoder reliability for 30 subsections of *Modern Biology* text produced the following results (Holsti, 1969):

Coding for Emphasis

$$C.R. = \frac{2M}{N_1+N_2}$$

where M = total coding agreements
N_1 = number of items checked by rater #1

$$C.R = \frac{2(29)}{34+35} = \frac{58}{69} = .84$$

where N_2 = number of items checked by rater #2

This ratio of the coding agreements to the total number of coding decisions was adjusted to take into account agreement that may have occurred by chance in accordance with the index of reliability (pi) developed by Scott (1955).

$$pi = \frac{\text{\% observed agreement} - \text{\% expected agreement}}{1 - \text{\% expected agreement}}$$

$$pi = \frac{.84 - .225}{1-.225} = .79$$

Coding for Themes (using the same techniques)

$$C.R = \frac{2m}{N_1+N_2}$$

$$C.R. = \frac{2(16)}{19+17} = .89$$

$$pi = \frac{\text{\% observed agreement} - \text{\% expected agreement}}{1 = \text{\% expected agreement}}$$

$$pi = \frac{.89 - .158}{1 - .158} = \frac{.732}{.842} = .87$$

Ref: Holsti, Ole R., *Content Analysis for the Social Science and Humanities*, Addison-Wesley Publishing Company, Reading, Massachusetts, 1969, pp. 135-141.

Scott, W. A., "Reliability of Content Analysis: The Case of Nominal Scale Coding," *Public Opinion Quarterly*, Vol. 19, 19 , pp. 321-325.

INSTRUCTIONS FOR CODING

Each subsection should be coded for *Emphasis* and *Themes*. When coding, each subsection should be judged as if it were an isolated entity. The overall context in which it appears *should not be assumed* by the coder, unless otherwise indicated in the guidelines.

CODING FOR EMPHASIS

Code each subsection with respect to its predominant emphasis. The stress of subsection is determined by asking what the main points of the subsection are and what categories they pertain to. Main points are generally suggested by the title of the subsection and the first sentence in the various paragraphs.

DETERMINING THE NUMBER OF CATEGORIES TO CODE

For subsections two paragraphs or less in length:

Subsections two paragraphs or less in length should be coded in only one of the Emphasis categories. For a one paragraph subsection, determine what the main point of the paragraph is and code the most appropriate category.

In two paragraph subsections where there appears to be more than one category stressed in the text, code the category reflected in both paragraphs. If the paragraphs emphasize material falling into two completely different categories, code the emphasis most reflected in the first paragraph.

(Note that the entire subsection should be coded for themes, however.)

For subsections that are more than two paragraphs in length:

(It is appropriate to code more than one category. However, the coder should be careful to only code a category when the subsection clearly stresses material pertinent to that category.)

For subsections longer than two paragraphs:

1. Always code the emphasis evidenced in the first paragraph as if it stood alone. (Except in cases where the first paragraph has no substantive stress and the remainder of the subsection is substantive. In such cases, code the stress of the remainder as appropriate and do not code the introductory paragraph.)
2. Code the emphasis stressed in the remainder of the subsection as appropriate, using the main points criteria to determine stress.

3. In general, more than two sentences relevant to the category must appear for a category to be "stressed." (An exception is a case where the first paragraph is two sentences or shorter.)

Certain guidelines below (starred) will help you determine the proper number of categories to code.

CRITERIA FOR CODING CATEGORIES

Molecular-Cellular:

Code this category is a focus of the subsection is:

- The chemical composition or organisms.
- Chemical reactions or energy transformations that take place within organisms.
- The morphology of cells.
- Functions of cells and their substructures.
- The movement of materials into and out of cells.

Molecular-Cellular Guidelines:

- Code a subsection that discusses chemical reactions within the *explicit* or *implicit* context of living organisms here. Such discussion is to be distinguished from background information on chemistry (e.g., a description of chemical bonds) that is coded in the Science Discipline section described below.
- * o If a subsection discusses the movement of substance from cell to cell with the explicit intent of demonstrating how an organism receives nourishment, code both the Molecular-cellular and Organ-tissue-morphology categories. (If subsection is less than two paragraphs, code only Mollecular-cellular.) However, code a subsection that describes movement of substances through the cell wall outside the context of the purpose of that movement under Molecular-cellular *only*.
- * o Code discussions of genetic determination of specific traits under Molecular-cellular *only*--even when the remainder of the section stresses descriptions of the morphological or behavior manifestations of the genetic make-up.
- * o Code a discussion of the effects of external conditions (e.g., light) on an internal process (e.g., photosynthesis, pigment

production) at the level of the process (e.g., cellular-molecular, organ-tissue-morphology) *only*. The theme organism-environment will be appropriate in these cases. (Note the exception of tropisms.)

Example of statements dealing with this level:
(from biology teachers' handbook)

1. Often the simple sugars are bonded together to form more complex sugars. Simple sugars can be oxidized to release energy. When they are, they form water and carbon dioxide. (molecular)
2. The enzyme maltose acts as follows. The maltose molecule must collide with the enzyme molecule and adhere to it... (molecular)
3. Biological work uses *chemical bond* energy, specifically, the energy present in molecules of one specific compound, adenosine triphosphate (ATP). The special character of this compound depends on the presence in it of high energy phosphate bonds. (molecular)
4. The site of all the enzymes that break the glucose molecule down from the pyruic acid stage is the mitochondrion--a small body barely visible under the best light microscopes. (cellular)
5. The most striking events in mitosis concern the chromosomes. They are nearly always invisible in nondividing cells. As mitosis gets under way, however, they become increasingly visible, with definite boundaries. (cellular)
6. Materials pass from and into the interior of cells by way of the cell membrane. Three different processes may be involved in this transport across a membrane. (cellular)

Organ-Tissue-Morphology:

Code this category if a focus of the subsection is:

- The function or structure of organs; how substances produced by organs affect the organism.
- The structure or function of tissues.
- Systems composed of organs and tissues in living organisms (including the skeletal, muscular, digestive, nervous,

endocrine and reproductive systems); the structure of function of these systems.

- o Morphology -- the form or structure of the organism as a whole, distinctive anatomical or physiological characteristics of single members of a related group of biological organisms.
- o The classification or organisms into groups according to distinctive features (see guidelines).

Organ-Tissue-Morphology Guidelines:

- ★ o Code any discussion of the classification of organisms or criteria for plant and animal classification here. Code subsections that make *explicit* reference to Taxonomy under History-Scientific Processes and under Organ Tissue Morphology *if* the subsection is longer than two paragraphs (i.e., reference to taxonomy assumes reference to classification by features). If the subsection is two paragraphs or less and makes reference to Taxonomy, only code under Organ Tissue Morphology.
- o A subsection that discusses the changes in the form or function of a single organ or system over time should *not* be coded here, but instead should be coded under the Behavior-Population-Biome category.
- o Code discussions of plant or animal growth or factors affecting plant or animal growth at the Organ-Tissue-Morphology level (except for discussions of tropisms that are coded at the Behavior-Population-Biome category).
- o In general, processes occurring outside the individual cells, but within the organism are coded in the Organ-Tissue-Morphology category. (But see above for rules on transport between cells.)
- o Single celled (or smaller) organisms (i.e., viruses, protozoa) are considered to be organisms--not cells.
- ★ o Any descriptive discussion of the characteristics of an organism (or group of organisms) that provides a general overview of form, function, structure, distribution and behavior (e.g., provides a few sentences on many aspects of that kind of organism) should be coded under Organ-Tissue-Morphology *only*.

- * o Code subsections that discuss the structure and/or function of cells that comprise an organ or system here (i.e., if cells are discussed within the context of an organ or system code here).
- o Code discussions of physiological aspects of plant or animal reproduction at the Organ-Tissue-Morphology level. Code discussions of behavioral aspects of plant or animal reproduction in the Behavior-Population-Biome category.
- o Code discussions of the life cycle of an organism (its physiological history from birth to death) in the Organ Tissue Morphology level.

Example of statements dealing with this level:
(from Biology Teachers' Handbook)

1. Much of the blood flows from the heart to the body and back again in less than a minute. (organ and tissue)
2. We do not yet know just how the products of the thyroid gland do their work, but in some way they control the rate at which our tissues release energy. (organ and tissue)
3. Root systems perform two additional functions. They absorb water and nutrient salts from the soil and provide conducting tissue for the transport of these materials. (organ and tissue)

Behavior-Population-Community-Biome:

Code this category if a focus of the subsection is:

- o The behavior of an organism as an individual, how it develops patterns of behavior without learning; how the individual learns; how it carries out fundamental processes such as courting, mating, resting, food procurement.
- o How organisms communicate.
- o Population - a large number of individuals that share some important features; the dynamics or activities of a population.
- o Community - a group of plants and animals living together in the same place. The community of interacting organisms

is often called an ecosystem; the dynamics or activities of a community.

- o Biome - in each major kind of climate, a characteristic vegetation tends to develop and maintain itself. Such a recognizable vegetation, together with the animal life adapted to it is a biome, the interrelationships of organisms and resources within a biome.
- o World Biome - all organisms are part of one worldwide web and all the organisms in the web are tied to the matter and energy of the non-living world. The worldwide web is the world biome.

Behavior-Population-Community Biome Guidelines:

- o Code discussions of tropisms here.
- o Code discussions of nutritional relationships such as commensalism and symbiosis here.
- * o Most discussions about evolution should be coded here. This includes discussion of characteristics of populations over the course of many generations and processes through which these characteristics change over time. Discussion of mutations related to adaptation often mention changes that occur at a cellular level. However, when such discussion is intended to demonstrate a process by which speciation takes place, the subsection should be coded in this category *only*.
- o Code discussions of habitats or distribution of a group of organisms here.
- o Code discussions of vestigial and homologous organs here.

Example of statements dealing with this level:
(from biology teachers' handbook)

1. Studies have shown that innate behavior patterns are rarely a reaction to the environmental situation as a whole but only to a few parts of it. Other parts are entirely ignored. (behavior)
2. The male stickleback isolates himself in the spring, develops a nuptial dress of whitish blue on the back and brilliant red on throat and belly, and selects a territory which it defends against other males. (behavior)

3. Accumulated evidence makes it probable that the "imprinting" process is quite different from learning as we know it so far. For example, imprinting seems to occur -- when it occurs -- almost instantaneously. Neither periods of trial nor numerous repetitions are required. (behavior)
4. Population size, then, may decrease by mortality or emigration and increase by natality and immigration. (population)
5. At the University of Wisconsin, the mouse population increased rapidly at first until the living space became crowded. At this point, chasing, fighting, and cannibalism increased drastically. . . . Eventually, the mortality of the young reached 100%. (population)
6. Sometimes unusual climatic conditions upset the equilibrium. A shift in weather conditions for an epidemic which will return the population to an earlier stage of growth. (population)
7. A soil is a biological system that consists of a group of interacting organisms living in a special sort of inorganic environment. It is an ecosystem. . . . In the total economy of the biological community bacteria are the primary decomposers. . . . (community)
8. In the case of mosquitoes, men and malaria, the parasite has a complex life history which involves both hosts. . . . Insects may serve as vectors of pathogens in a purely mechanical way. (community)
9. Since the bulk of pond producers are microscopic, we would expect the first-order consumers to be small. And so they are. Many of the consumers are themselves a part of the plankton. They are protists-ciliates and flagellates. (community)
10. Already, the presence of so many human beings has brought stress to the lives of most kinds of plants and animals, from the tundras to the equator and as far south as inhabitable land exists. Everywhere,

the number of species is shrinking, the food webs are tearing. . . . (biome)

11. The whole natural system, in an analogous way, tends toward balance, equilibrium, at any given time; yet it is subject to changes, both short-term and long-term. (biome)

12. If, as we assumed, there was little or no oxygen in the atmosphere of the early earth, the evolution of early forms of life could not have occurred until oxygen was made available. We think that photosynthesis was the means by which free oxygen, over millions of years, was made available in the atmosphere. (biome)

Applied Field:

Code this category if a focus of the subsection is:

- o Hygiene; diseases, their causes, manifestations, treatment or control; pharmaceuticals; drugs; nutrition.
- o Resource conservation or management.
- o Industrial or economic aspects of biology.
- o Agriculture, farming, food technology.
- o Technique — a standard procedure for accomplishing a specific task. A technique has a specified outcome known in advance.
- o Applications of scientific knowledge to solve practical problems.

Applied Field Guidelines:

- o Code subsections that discuss alcoholism or drug problems here, even if the subsection focuses on the behavior of the alcoholic or the addict.
- * o For subsections that describe a disease and are two or less paragraphs code Applied. If the subsection is more than two paragraphs code Applied and Organ Tissue Morphology if two or more sentences describe the etiology of the disease.
- o If a technique is being described and the subsection is more than two paragraphs code the category for which the technique is applicable if it is clearly applicable to another category.

Science Discipline:

Code this category if a focus of the subsection is:

- o Presenting information from a scientific discipline other than biology (e.g., chemistry, earth science, physics). Such discussions generally provide background information for discussions on biological organisms occurring later in the chapter.

Science Discipline Guidelines:

- * o Code a discipline other than biology (except chemistry) when material from biology is mixed with material from another discipline if:
  - a) Terms from that discipline are highlighted (put in boldface or italics) or
  - b) At least one paragraph is devoted solely to the non-biological discipline (i.e., there is no biological information woven into the paragraph).

If possible, code a category other than the Science Discipline category when the material is interwoven in this way.

For subsections two paragraphs or less, follow the rules laid out earlier.

History-Scientific Processes

Code this section if a focus of the subsection is:

- o The general methods through which scientific knowledge is generated.
- o A study or group of studies undertaken to explore questions of scientific interest.
- o How people thought about aspects of biology at different points in history.
- o The nature of science, the kinds of questions different scientists attempt to answer.

History-Scientific Processes Guidelines:

- o Note that subsections coded here frequently describe studies or discuss the fact that scientists undertook studies to yield knowledge relevant to some aspect of an organism. Should this be the case, both the appropriate level and History-Scientific Processes should be coded. Thus a description of Mendel's work on genetic inheritance would be coded under Molecular-Cellular and History-Scientific Processes and a description of an experiment on animal learning would be coded under Behavior-Population Community-Biome and History-Scientific Processes.

- * o Code a discussion of "ancients" or "once held" beliefs under History Scientific Processes only. In subsections longer than two paragraphs it is appropriate to code additional stressed categories for those portions of the subsection dealing with modern knowledge.

Non-Substantive

Code this category if:

- o None of the above categories are applicable.

Non-Substantive Guidelines:

- o Coding in this category usually indicates that there is little substantive content to the subsection. An introductory section that suggests many topics that will be covered may, for instance, have no real substantive focus and should be coded here.
- o Code descriptions of hobbies and activities the student might undertake for "fun" or "hobbies" here.

CODING FOR THEMES

Examine each subsection to determine if one or more of the themes described below are reflected in the subsection. Themes should be coded only when explicity apparent, that is when it is possible to underline the words that indicate the pressence of the theme. *Not every subsection will evidence a theme.*

Theme 1: Complementarity of Structure and Function

- o Check this category if the subsection relates biological structure to biological function in such a way as to illustrate why a particular structure is suited to a particular function.
- o Check this category if the subsection demonstrates that biological structure can be used to infer biological function.

Complementarity of Structure and Function Guidelines:

- This theme *should not be* checked if the text merely indicates that a particular structure has a certain function. To be included in this category the text *must explicitly demonstrate* why the structure is suited to the function.

Theme 2: Complementarity of Organism and Environment

- Check this theme if the subsection explains how the function or dynamics of a biological entity (e.g., cell, organ, individual, population) are influenced by its environment.
- Check this theme if the subsection explains how a biological entity (e.g., cell, organ, individual, population) modifies the environment in which it exists.

Complementarity of Organism and Environment Guidelines:

When coding the organism-environment theme for passages that have a Behavior-Population-Biome emphasis, be sure the subsection does more than merely state that an organism operates within a particular environment. To be coded the passage should suggest that the variation of some environmental dimension affects some aspect of the physiology behavior distribution of an organism. Thus the sentence "The robin feeds on insects he finds under rocks" should not be coded for this theme. Whereas the sentence "Many birds have been poisoned by high levels of insecticides in the air" would be coded for organism-environment.

Theme 3: Change of Living Things Through Time

- Check this theme if the subsection describes the history of organisms -- the sequence of events in past time from which the biological present has had its origins.
- Check this theme if the subsection describes the processes through which organisms evolve over time (e.g., natural selection, adaption, mutation).

Subsection	Molecular Cellular	Organ Tissue Morphology	Behavior Population Biome	Applied Field	ce Discipline	History Scientific Processes	Non-Substantive	Structure Function	Evolution	Organism Environme

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